Report Documentation Page

Form Approved
OMB No. 0704-0188

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1. REPORT DATE **2008**	2. REPORT TYPE	3. DATES COVERED **00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE **An Examination of Options to Reduce Underway Training Days Through the Use of Simulation**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Rand Corporation,1776 Main Street,PO Box 2138,Santa Monica,CA,90407-2138**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**139**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

This product is part of the RAND Corporation monograph series. RAND monographs present major research findings that address the challenges facing the public and private sectors. All RAND monographs undergo rigorous peer review to ensure high standards for research quality and objectivity.

An Examination of Options to Reduce Underway Training Days Through the Use of Simulation

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Jerry M. Sollinger, Alisa Rhee

Prepared for the United States Navy
Approved for public release; distribution unlimited

RAND NATIONAL DEFENSE RESEARCH INSTITUTE

The research described in this report was prepared for the United States Navy. The research was conducted in the RAND National Defense Research Institute, a federally funded research and development center sponsored by the Office of the Secretary of Defense, the Joint Staff, the Unified Combatant Commands, the Department of the Navy, the Marine Corps, the defense agencies, and the defense Intelligence Community under Contract W74V8H-06-C-0002.

Library of Congress Cataloging-in-Publication Data

An examination of options to reduce underway training days through the use of simulation / Roland J. Yardley ... [et al.].
p. cm.
Includes bibliographical references.
ISBN 978-0-8330-4507-2 (pbk. : alk. paper)
1. Naval education—United States—Simulation methods. 2. Destroyers (Warships)—United States. 3. Marine engineering—Computer simulation. 4. Sailors—Training of—United States. I. Yardley, Roland J.

V411.E83 2008
359.5'6—dc22

2008032643

Cover Photo: Gas Turbine Systems Technician (Electrical) 3rd Class Chris Withers monitors the ship's online generators while standing watch at the electrical plant control console in damage control central aboard Arleigh Burke-class guided-missile destroyer USS Shoup. U.S. Navy photo by Mass Communication Specialist 3rd Class James R. Evans.

Published 2008 by the RAND Corporation
1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
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4570 Fifth Avenue, Suite 600, Pittsburgh, PA 15213-2665
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Preface

U.S. Navy surface combatant ship crew training involves a combination of shore-based, onboard pier-side, and underway training. Underway training is expensive and it increases wear and tear on operating equipment. Constrained budgets and increasing recapitalization costs have forced the Navy to examine various methods—such as increased use of simulators—to reduce the annual operating costs of the fleet. Although the Navy's surface combatant community currently uses simulators in its training regimen, an increased use of simulation could improve training efficiency, sustain training readiness, and potentially reduce underway days.

Recognizing the challenge and identifying an opportunity to better exploit simulation, the Deputy Chief of Naval Operations for Resources, Requirements, and Assessments, Assessment Division (OPNAV N81), asked the RAND Corporation to examine training requirements, determine where credit is granted for the use of simulation, estimate the current use of underway days, examine simulation technology, and identify the potential for greater use of simulation. This book contains the results of that research. It should interest those concerned with the training and readiness of Navy surface combatants, including members of the Fleet Forces Command, the Type Commander, and the broader defense operational planning and budgeting community.

The research was sponsored by OPNAV N81 and conducted within the Acquisition and Technology Policy Center of the RAND National Defense Research Institute, a federally funded research and

development center sponsored by the Office of the Secretary of Defense, the Joint Staff, the Unified Combat Commands, the Department of the Navy, the Marine Corps, the defense agencies, and the defense Intelligence Community.

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Summary

The U.S. Navy trains its surface combatant ship crews through a combination of shore-based, onboard pier-side, and underway training. Much of this training has traditionally involved significant periods of underway time, which allows units to achieve required certifications and readiness levels. Underway training is expensive, however, because fuel and consumables are expended while a ship is underway; wear and tear on operating equipment also drive up maintenance costs. One day's worth of fuel for one surface combatant costs approximately $40,000.[1] Tight budgets and increasing recapitalization costs have forced the Navy to examine various methods to reduce the annual operating costs of the fleet.

Technological improvements have increased the fidelity and realism of simulators, and simulation is being used more widely for training within the U.S. Navy, in other navies, and in commercial shipping companies. Although the Navy's surface combatant community currently uses simulators in its training regimen, an increased use of simulation could improve training efficiency, sustain training readiness, and potentially reduce underway days.

[1] This figure is based on the cost of fuel in fiscal year 2007, when oil cost approximately $70 per barrel. Fuel costs have since spiked, suggesting that any savings derived from substituting simulation for underway training would be even greater.

Purpose and Methodology

The Navy's Assessment Division asked RAND to examine the training requirements of surface forces, determine where credit is granted for the use of simulation, estimate what training gets done underway, examine simulation technology, and identify areas where simulation could be substituted for underway training without any decrease in readiness.

We focused our research on the DDG-51 Arleigh Burke–class surface combatants, and did so for two reasons. First, the DDG-51 class has the greatest number of ships in the surface combatant fleet (there are 50), and more are under construction. This provided a large data set for our analysis of training exercises performed. Second, if efficiencies could be realized through a greater use of simulation, those efficiencies would apply to the largest ship class in the Navy, thereby offering large economies of scale as well as applicability to new ships.[2]

This research identified underway training requirements for surface combatants for unit-level training (ULT), the number of underway days required to accomplish that training, and where credit for meeting training requirements through the use of simulation is currently granted. In addition, we identified which training requirements can only be completed underway, which can be completed in port without simulation, and which can be completed in port via simulation. We then surveyed available simulation technologies to determine if they could be substituted for training that is currently being performed underway.

Findings

What Training Is Done Where

The crews of surface combatants perform exercises in 15 mission areas that range from mobility exercises of seamanship, navigation, and engi-

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[2] New Arleigh Burke destroyers (i.e., DDG-97s and above) are being built with an embedded engineering training capability.

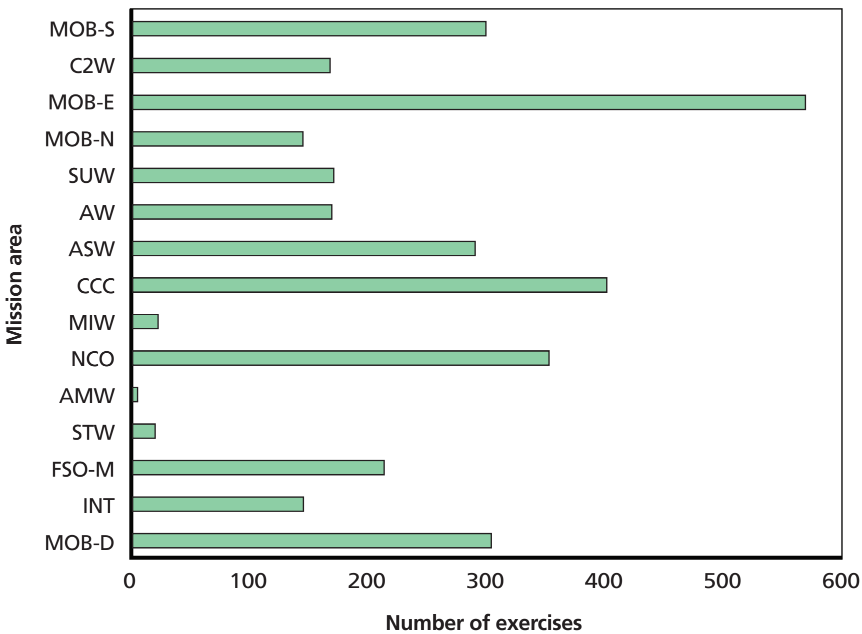
neering to tactical exercises such as air warfare, antisubmarine warfare, and surface and strike warfare. The 15 mission areas for surface combatants are

- mobility-seamanship (MOB-S)
- mobility-engineering (MOB-E)
- command and control warfare (C2W)
- mobility-navigation (MOB-N)
- surface warfare (SUW)
- air warfare (AW)
- antisubmarine warfare (ASW)
- command, control, and communications (CCC)
- mine warfare (MIW)
- noncombat operations (NCO)
- antimine warfare (AMW)
- strike warfare (STW)
- fleet support operations–medical (FSO-M)
- intelligence (INT)
- mobility–damage control (MOB-D).

The Navy's *Surface Force Training Manual* (SURFTRAMAN) specifies the training exercises that surface combatants must complete to sustain readiness.

To determine which training exercises are currently accomplished while a ship is underway, we created a database that lists completed training exercises as reported by DDG-51s. We then overlaid this information with the ship employment schedules, which we used to determine whether a ship was underway or in port when it reported each exercise complete. Figure S.1 shows the number of exercises completed by underway DDG-51–class ships that commenced and completed ULT in calendar year (CY) 2004. The data indicate that more than 70 percent (3,500) of CY 2004 ULT exercises were completed while ships were underway. They also show that engineering (i.e., MOB-E) exercises were the ones completed most often during ULT underway periods.

Figure S.1
Number of Exercises Completed by Underway DDG-51–Class Ships in ULT, by Mission Area, CY 2004



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Simulation Could Potentially Reduce Underway Training

The Navy's Surface Warfare Officer School (SWOS) in Newport, Rhode Island, has an extensive simulation capability to train prospective engineering department heads and engineering officers of the watch. As noted above, engineering training is a major driver of underway time in ULT.

An increased use of simulation for training engineering watchstanders could reduce the need for underway training. Increased repetitions through simulation might also make underway training more effective because watchstanders will have had more practice performing engineering drills and evolutions.[3] It can be challenging to establish the

[3] Training literature indicates that team training works when the training is driven by theory, focused on required competencies, and designed to provide trainees with realistic

correct level of complexity for a watch section manned by both newly qualified and experienced personnel at sea. Newly qualified personnel need to master the basics, whereas experienced personnel require challenging drills to reach peak effectiveness. An engineering simulator can be used to provide increased opportunities for junior (and senior) personnel to practice and receive feedback. The Navy already uses simulators to train personnel in engineering tasks, and these simulators are widely seen as providing credible training.

The Afloat Training Group (ATG), Atlantic, recognizes the value of the SWOS's full-mission engineering simulators to train prospective engineers. At the end of the training curriculum, ATG assessors are flown from Norfolk, Virginia, to Newport, Rhode Island, to assess prospective engineers' performance of engineering drills and evolutions on the full-mission simulator.

Performing engineering casualty control (ECC) drills underway is not identical to doing them in a simulator. Differences include physiological sensations (e.g., sound, smell, sight, and movement of the ship) as well as differences in activities and communications. Shipboard activities and communications include interactions (e.g., reports, logs, and evolutions) among central control station (CCS) watchstanders (who man the propulsion and electric-plant control consoles), engine room and auxiliary space watchstanders, and the bridge. The quality and fidelity of a simulator also accounts for differences. A high-quality, high-fidelity simulator that accurately represents the characteristics of onboard equipment minimizes the differences between onboard ECC drills and those conducted in a simulator.

Other Options to Reduce the Need for Underway Training

Our analysis also indicates that many other exercises performed underway could be done in port. We examined where exercises *could* be completed (i.e., underway or in port) and where they *actually* were com-

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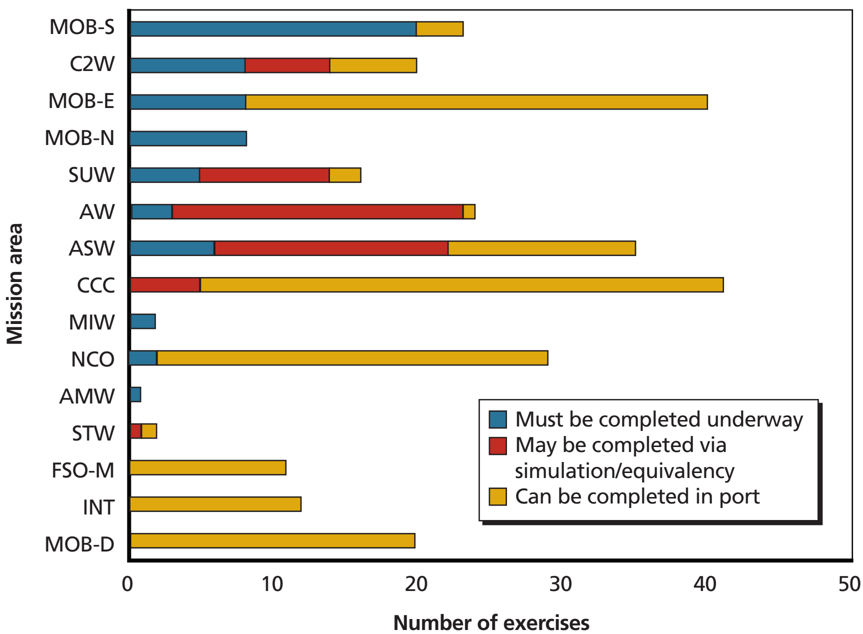
opportunities to practice and receive feedback. See Eduardo Salas and Janis A. Cannon Bowers, "The Science of Training: A Decade of Progress," *Annual Review of Psychology*, Vol. 52, 2001, pp. 471–499. Evolutions are actions such as aligning, starting, and stopping ship's engineering equipment and systems such as fuel oil, lube oil, chilled water, sea-water service, and firemain.

pleted. Figure S.2 shows, by mission area, the total number of exercises that DDG-51–class ships must complete. It also shows how many exercises can only be completed underway (shaded in blue), how many may be completed in port using simulation (shaded in maroon), and how many can be completed in port without simulation (shaded in yellow).

Seamanship and navigation mission areas contain the highest percentage of exercises that must be done underway. Seamanship exercises include activities such as replenishment at sea and getting underway from a pier or mooring. Navigation exercises include harbor transit, piloting by gyrocompass, and low-visibility piloting. These exercises require total ship integration and coordination—of the bridge, combat information center, engineering watch teams, and special evolution teams—and although ship-handling simulators exist and are used by

Figure S.2
Number of Exercises Required for DDG-51–Class Ships, by Mission Area and Location



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ship crews, no equivalencies are granted for their use.[4] Therefore, these exercises are done underway.

Our review of the data indicates that although most exercises are done underway, many could be done in port. We do not know if ships complete exercises underway because the ships already are underway, or if the ships get underway to complete the exercises. The fact that most of the training for ULT is done underway may be due to culture, policy, or practice. In-port time for engineers can be dominated, among other demands, by maintenance needs and equipment upgrades that cannot be accomplished at sea. In addition, underway training offers the ship's commander a unique opportunity to exercise most of the ship systems when the entire crew is present and focused on training. However, this does not mean that other training approaches cannot train crews to an acceptable level of proficiency.

We explored opportunities where using simulation might reduce underway training for DDG-51–class surface combatants. We focused on engineering training, a major driver of unit-level underway training, and explored options to sustain in-port readiness through the use of simulation. Our findings offer a potential solution to supplement and sustain the readiness of DDG-51 engineering CCS personnel through the use of an engineering simulator. The Navy's surface combatant community might be able to use an engineering simulator (similar to the one used at SWOS) for DDG-51–class ships. These simulators could be placed at the fleet training centers in major homeports to better prepare crews for underway engineering training and to make the use of underway time more efficient.

We also found that the DDG-51s currently being fielded have embedded training simulators that enable crews to train via simulation while using actual operational equipment. These simulator suites (provided through the Total Ship Training System upgrade) are being retrofitted on ships that are currently in service, but this is occurring at the relatively slow rate of two or three two ships per year.

[4] The equivalency certification means that an exercise conducted on the simulator counts toward readiness reporting.

Recommendations

In light of our findings, we recommend that the Navy take the following three actions.

1. Invest in shore-based DDG-51 engineering simulators and place them at fleet concentration areas (FCAs). Wider use of engineering simulators at FCAs might reduce costs and increase watchstander proficiency in the performance of ECC exercises through increased repetitions and practice. Investing in such simulators appears to be cost effective. An engineering simulator similar to the one used at SWOS would cost approximately $1.6 million (not including sustainment costs). Given that fuel alone costs $40,000 per steaming day per DDG-51, it only takes a reduction of 40 steaming days to offset the simulator acquisition costs. As fuel costs increase, the number of underway days needed to offset the simulator acquisition decreases.

2. Take other actions to reduce underway days for ULT by completing more exercises in port. Our analysis indicates that many or most MOB-E, CCC, NCO, MOB-D, and FSO-M exercises could be done in port. To reduce underway training days, the Navy should direct those exercises that *can* be done in port indeed *must* be done in port.

3. Consider accelerating the installation of upgrades that provide DDG-51–class ships with an embedded engineering training capability that allows training to be performed onboard on the ship's equipment. The Navy is retrofitting DDG-51–class ships with an embedded engineering training capability through Total Ship Training System upgrades. Naval Sea Systems Command officials indicate that these installations are proceeding at a pace of one to two DDG-51s per year. Accelerating the rate of the installations would provide more ships with an embedded training capability and allow more training to be done in port on the ship's own equipment. These measures could produce cost savings. The costs, benefits, and feasibility of this approach must be evaluated.

Acknowledgments

The project team would like to thank the staff of OPNAV N81 for their support, especially Ms. Nancy Harned, CAPT Catherine Osman, CAPT James Brown, and Mr. Stephen Williams. We appreciate the guidance provided by RADM Daniel Davenport and Mr. Trip Barber.

Our efforts were supported by the U.S. Navy training commands responsible for surface force combatant training. We appreciate the time provided to us by Commodore Bill Valentine, Commander, ATG, Atlantic, and by Commodore Faris Farwell, Commander, ATG, Pacific, and by their respective staffs. In particular, CAPT Michael Boyd and Mr. Barry Walsh (Pacific) and LCDR Greg Spangler (Atlantic) were very helpful and responsive to our questions. We also benefited from discussions with CAPT Bill Johnson of Commander, Naval Surface Forces, Pacific, and CAPT Ken Krogman of Commander, Naval Surface Forces, Atlantic. Mr. Dan Rodgers of Commander, Naval Surface Forces, Pacific, was a valuable resource to the research team as he answered many questions related to the issues and challenges of scheduling surface combatant underway training.

Mr. Dick Arnold of Commander, THIRD Fleet, and CAPT Neil May of Commander, Strike Force Training Pacific, were very helpful in discussing the successes and challenges associated with training and preparing Carrier and Expeditionary Strike Groups to deploy. We appreciate the support provided to us by Commander, Fleet Forces Command, especially the efforts of Mr. Russ Williams and Ms. Linda Arnold. We thank CAPT Bill Kovach of Tactical Training Group,

Atlantic, for the time and effort he dedicated to discussing the myriad details that go into planning integrated and sustainment training for carrier and expeditionary strike groups.

We appreciate the time and effort of the SWOS Executive Director, Mr. George Ponsolle, and his staff, who arranged our tour of SWOS facilities and discussed the school's training and simulation capabilities. Mr. Finn Kilsgaard of Naval Air Systems Command Training Systems Division Orlando, was very helpful in discussing the capabilities, limitations, and costs of the DDG-51 engineering simulators at SWOS.

We also thank Erin-Elizabeth Johnson for editing the manuscript, Lynn Rubenfeld for coordinating the document's production, and Carol Earnest for her work on the figures. We are grateful to RAND colleagues John Ausink and Mark Happel for their extensive and thoughtful suggestions on an early draft of the report, and to Laurence Smallman for providing information about the Royal Navy's use of simulation. We acknowledge and appreciate the administrative support provided by Jennie Breon.

The views expressed herein are our own and do not necessarily represent the policy of the Department of the Navy.

Abbreviations

AAW	anti-air warfare
AFFF	aqueous film forming foam
AMW	antimine warfare
ASM	antiship missile
ASMD	antiship missile defense
ASW	antisubmarine warfare
AT/FP	antiterrorism/force protection
ATG	Afloat Training Group
ATGPAC	Afloat Training Group, Pacific
AW	air warfare
BS&W	bottom sediment and water
C2W	command and control warfare
CAE	Computer-Aided Engineering
CART	Command Assessment of Readiness and Training
CCC	command, control, and communications
CCS	central control station
CIC	Combat Information Center

CIWS	Close-In Weapons System
COMNAVSURFOR	Commander, Naval Surface Forces
COMPTUEX	composite training unit exercise
COMSECONDFLT	Commander, Second Fleet
COMTHIRDFLT	Commander, Third Fleet
COVE	Conning Officer Virtual Environment
CPP	controllable pitch propeller
CRP	controllable reversible pitch
CSG	Carrier Strike Group
CSOSS	combat systems operational sequencing system
CSSQT	Combat Systems Ship Qualification Trials
CY	calendar year
DCC	damage control console
DLQ	deck-landing qualification
ECC	engineering casualty control
ECM	electronic countermeasures
ECSS	Extendable Computer System Simulator
EEBD	emergency escape breathing device
EOOW	engineering officer of the watch
EOSS	engineering operational sequencing system
EOT	engine order telegraph
EPCC	electric plant control console

EPCC	electric plant control console
ESG	Expeditionary Strike Group
ESS	electronic systems spaces
ETT	Engineering Training Team
EW	electronic warfare
F/O	fuel oil
FATS	firearms training system
FCA	fleet concentration area
FEP	final evaluation period
FMB	full mission bridge
FMERS	Full Mission Engine Room Simulator
FRP	Fleet Response Plan
FSO-M	fleet support operations–medical
FST	fleet synthetic training
FST-U	fleet synthetic training–unit
FTC	Fleet Training Center
FY	fiscal year
GTG	gas turbine generator
GTM	Gas Turbine Module
GTPPT	Gas Turbine Propulsion Plant Trainer
HPAC	high-pressure air compressor
I/ITSEC	Interservice/Industry Training, Simulation and Education Conference
INT	intelligence

JTFEX	joint task force exercise
L/O	lube oil
LAMPS	Light Airborne Multi-Purpose System Aircraft
LCS	littoral combat ship
LOP	local operating panel
LPAC	low-pressure air compressor
LPAD	low-pressure air dehydrator
MCM	mine countermeasures ship
MCO	major combat operations
MCO-R	MCO-ready
MCO-SR	MCO–surge ready
MHC	coastal mine hunter
MIW	mine warfare
MMTT	multimission team trainer
MOB-D	mobility–damage control
MOB-E	mobility-engineering
MOB-N	mobility-navigation
MOB-S	mobility-seamanship
MPRI	Military Professionals Resources, Inc.
MRG	main reduction gear
MSS	maritime security surge
NCO	noncombat operations
NTA	Navy tactical task

NTDS	Navy tactical data system
OBT	onboard trainer
OOD	officer of the deck
OPNAV N81	Deputy Chief of Naval Operations for Resources, Requirements, and Assessments, Assessment Division
PACC	propulsion and auxiliary control console
PCC	propulsion control console
PECS	Pump and Engine Control System
PLA	power level actuator
PLC	Programmable Logic Controller
PLCC	propulsion local control console
PQS	Personnel Qualification Standards
RCO	readiness control officer
RDE	Rheinmetall
RFT	ready for tasking
RIMSS	Redundant Independent Mechanical Start System
S/W	sea water
SCC	ship control console
SCU	ship control unit
Ser	Serial
SORTS	Status of Resources and Training System
SPAWAR	Space and Naval Warfare Systems Center
SSC	Service School Command

SSDG	ships service diesel generator
SSG	Surface Strike Group
STW	strike warfare
SURFTRAMAN	Surface Force Training Manual
SUW	surface warfare
SWOS	Surface Warfare Officer School
SWS	sea-water service
SYSCOM	System Control
TAO	tactical action officer
TFOM	Training Figure of Merit
TORIS	Training and Operational Information System
TRMS	TYCOM Readiness Management System
TSTS	Total Ship Training System
TYCOM	Type Command
U/W	underway
ULT	unit-level training
ULTRA	ULT Readiness Assessment
ULTRA-C/E	ULTRA-Certification/Engineering
ULTRA-S	ULTRA-Sustainment
USS	United States Ship
VBSS	visit, board, search, and seizure

CHAPTER ONE

Introduction

Background

U.S. Navy surface combatant training involves a combination of shore-based, onboard pier-side, and underway training. All surface combatants train at sea to achieve required certifications, meet and sustain readiness goals, and prepare for deployed operations. Underway training provides a realistic setting that mimics the conditions a ship is expected to encounter during deployed operations.

A day at sea is a day of training, and there are many benefits to training underway. While underway, the commanding officer assesses crew strengths and weaknesses, and training plans are built to improve and maintain readiness for deployed missions and operations. At sea, the crew essentially trains around the clock: Watch stations are manned, equipment is monitored, and reports are made. Individuals must be trained and qualified in accordance with the Personnel Qualifications Standards (PQS) established for the watch stations they will man.[1] Unqualified crewmembers stand watch under the instruction of a PQS-qualified watchstander and knowledge is passed from one crewmember to the next. An under-instruction watchstander is

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[1] PQS is a formal system of standards for theory, systems, and watch qualifications. It delineates the minimum knowledge and skill sets an individual must demonstrate before standing watch or performing other specific duties necessary for the safe, secure, and proper operation of a ship, aircraft, or support system.

tested on knowledge and required actions;[2] upon satisfactory demonstration of knowledge and skills, he or she achieves the watchstanding qualification.

Underway team training is also conducted for the various watch teams (such as the bridge, combat information center, and engineering watch teams) that constitute the normal underway watch. Special evolution training is also performed for events such as underway replenishment, sea and anchor detail (for entering and leaving port and anchoring), and visit, board, search, and seizure (VBSS) evolutions. Many of these events require great knowledge, skill, practice, and teamwork and may involve many crewmembers. The quality of such underway training can vary widely depending on the plans and preparation for the training event, the realism of the drills, and the mechanisms used for evaluating and providing feedback on performance.

Although underway training is arguably the best method for training a crew, it is expensive and becoming even more costly. While underway, a ship consumes fuel, and fuel costs are both rising and unpredictable. Figure 1.1 depicts costs of fueling three types of surface combatants while the ships are underway and steaming in port.[3] Note that fuel costs were calculated in fiscal year (FY) 2007, when oil cost $70 per barrel.

Fuel for an underway training day for a DDG-51–class ship costs approximately $40,000. However, fuel is not the only cost. Consumables (e.g., lubricating oils, food) are also expended underway, and these costs are not captured in the figure. Furthermore, the wear and tear on machinery and other equipment and systems incurred when a ship is underway increase maintenance demands. These factors—fuel, other consumables, wear and tear, and associated maintenance demands—make underway days costly and deplete increasingly scarce operations and maintenance dollars.

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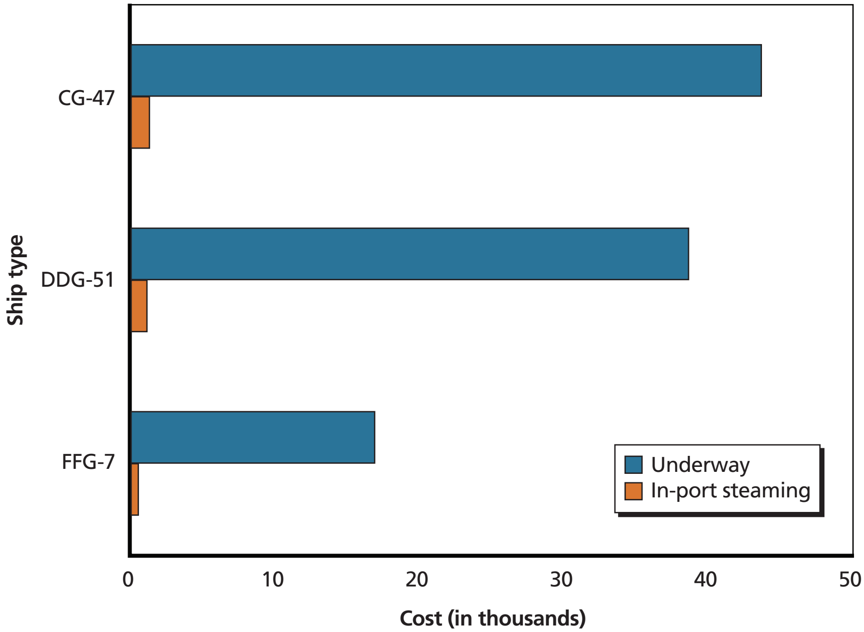
[2] Testing may involve a written or oral examination (or both) administered by a designated board that includes senior personnel.

[3] *In-port steaming* refers to a ship that is providing its own electrical and hotel (e.g., hot water, heat, fresh water) services. This condition is also known as *auxiliary steaming*.

Figure 1.1
Cost to Fuel Underway and In-Port Steaming of Surface Combatants, by Ship Type



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Other factors put pressure on the number of underway days that are devoted to training. Recently, a budgeting decision was made to reduce the number of nondeployed steaming (i.e., underway) days.[4] The Navy's FY 2008 budget reduces the surface combatant fleet's average per-ship nondeployed steaming days from 24 in FY 2007 to 22 in FY 2008 in anticipation of improved training methods and increased reliance on simulation exercises.

The cost of underway training and the reduction in nondeployed underway training days have two implications. First, a reduction in nondeployed underway days requires ships to make the most effec-

[4] Nondeployed underway time is used for training fleet units when they are not deployed. This training includes participation in individual unit training exercises, multi-unit exercises, joint exercises, and sustainment training.

tive use of the available underway time to complete required training and exercises. Second, the Navy is encouraged to find ways to perform training tasks in port through hands-on training or simulators.

The Vision for Unit-Level Training

Recently, there has been a concerted effort to reduce the number of underway training days required to complete unit-level training (ULT). The average time has already been reduced from 16 weeks to 13 weeks, and the intent is to reduce ULT even further. The long-term goal of Commander, Naval Surface Forces, is to achieve a continuous certification process and reduce biennial certification time to two or three weeks.[5] Surface combatants have taken up to 16 weeks to complete unit-level phase training, and the goal is to reduce this time by instituting a culture of continuous training and certification.

This goal raises questions: How will ULT certification be achieved in two to three weeks? How will the certification be sustained over the operational cycle? The Navy will strive to maintain continuous certification (and training) through effective self-assessment and more-frequent validations of assessments conducted by the Afloat Training Groups (ATGs).

Our research evaluated simulation technologies and how they might be used to reduce underway training. Simulation could help achieve VADM Etnyre's vision to reduce ULT time and enable training sustainment.

Research Objective

The Deputy Chief of Naval Operations for Resources, Requirements, and Assessments, Assessment Division (OPNAV N81), asked the

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5 *Continuous certification* means that a ship must be able to proceed to advanced training at any time. See VADM T. T. Etnyre, Commander, Naval Surface Forces, "Message from Commander, Naval Surface Forces," *Surface Warfare Magazine*, Vol. 32, No. 2, Spring 2007.

RAND Corporation to determine where the increased use of simulation might reduce underway days for surface combatants. Our research objective was to identify which ULT underway training requirements for surface combatants can be accomplished through a more extensive use of simulation. The research concentrated on the surface combatant community, and specifically on DDG-51 destroyers. The DDG-51 class has the greatest number of ships in the surface combatant fleet (there are 50), and more are in construction. The large number of ships in the DDG-51 class provided a large data set for our analysis of training exercises performed. Furthermore, if efficiencies could be realized through a greater use of simulation, those efficiencies could apply across the largest ship class in the Navy, thereby offering economies of scale.

This book reports on the following items:

- number of underway days used
- training requirements completed underway
- where credit for meeting training requirements is granted through the use of simulation according to the *Surface Force Training Manual* (SURFTRAMAN)
- where training events need to be performed (i.e., underway only, in port via simulation, or in port without simulation)
- simulation technologies used for training in the maritime industry, including other segments of the U.S. Navy, the U.K. Royal Navy, and the commercial maritime industry
- where a greater use of simulation might (1) increase operator proficiency and readiness and (2) reduce underway days.

The research required close work with the Type Commands (TYCOMs), the numbered fleet commanders, Fleet Forces Command, the ATGs, and other organizations concerned with training policies and effectiveness. The analysis builds on existing data, analytical tools, and domain knowledge that resulted from previous research.[6]

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[6] See Roland J. Yardley, Harry J. Thie, John F. Schank, Jolene Galegher, and Jessie Riposo, *Use of Simulation for Training in the U.S. Navy Surface Force*, Santa Monica, Calif.: RAND Corporation, MR-1770-NAVY, 2003; John F. Schank, Harry J. Thie, Clifford M. Graf II,

Our Methodology

To address the research goals, we first identified (1) the number of underway days used for ULT and (2) the specific types of training that are accomplished during these days (including the frequency of exercises). We then ascertained which exercises need to be done underway and which could be done in port, with or without simulation. We then surveyed available simulation technologies to determine whether they could be substituted for training currently being performed underway.

The methods we used were a training requirements review, a literature review, interviews with subject matter experts, data analysis, analysis of current underway and in-port training practices, and identification of simulation technologies and their suitability for accomplishing more training via simulation. We examined only technology-ready solutions (i.e., technologies that currently exist and could be used if the Navy decided to pursue them).

Organization of the Report

Chapter Two provides background information on surface combatant training for the unit-level, integrated, and sustainment phases. Chapter Three addresses DDG-51 training requirements, the number of underway days that ships use in ULT, and the exercises that were completed underway. In Chapter Four, we describe our assessment of training requirements, including what training must be done underway, what can be done in port via simulation, and what can be completed in port without simulation. We also address engineering training, a major driver of underway days, and provide details about engineering training requirements. In Chapter Five, we identify opportunities for the Navy to reduce underway training by using simulation to reduce underway training requirements. In Chapter Six we identify the exer-

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Joseph Beel, and Jerry M. Sollinger, *Finding the Right Balance: Simulator and Live Training for Navy Units*, Santa Monica, Calif.: RAND Corporation, MR-1441-NAVY, 2002.

cises that are done underway at a high frequency that can be conducted in port. In Chapter Seven, we summarize our findings and provide recommendations.

CHAPTER TWO

Overview of Navy Surface Combatant Training

Surface combatant training prepares a ship's crew for major combat operations (MCO), other missions in support of national defense needs, and the demands of the extended operations and occasional unplanned events experienced while deployed overseas. Surface combatant ships normally deploy as part of a Carrier Strike Group (CSG), Expeditionary Strike Group (ESG), or Surface Strike Group (SSG). The missions that a ship is trained to perform depend on the ship's role in the fleet (which is a function of the capabilities of the ship's weapon systems and equipment) and the exact missions that the ship is expected to perform during a given deployment. This chapter begins with an overview of how the Navy trains. Those familiar with naval training practices may choose to skip this description.

How the Navy Trains

All U.S. Navy ships operate under the Fleet Response Plan (FRP) cycle, where ships train to achieve readiness goals and then must sustain high readiness levels before, during, and after a deployment. The cycle is defined as the time from the end of one major maintenance period to the end of the next maintenance period. The FRP is designed to provide rotational deployed forces that meet combatant commanders' presence needs as well as forces capable of a surge response. The FRP cycle of readiness consists of four phases: maintenance, ULT, integrated, and sustainment training. A deployment to a forward theater of operations is part of the sustainment phase. Ideally, at the end of the sustainment

phase, the ship is scheduled to enter a shipyard for maintenance, repair, and modernization work, and the cycle recommences.

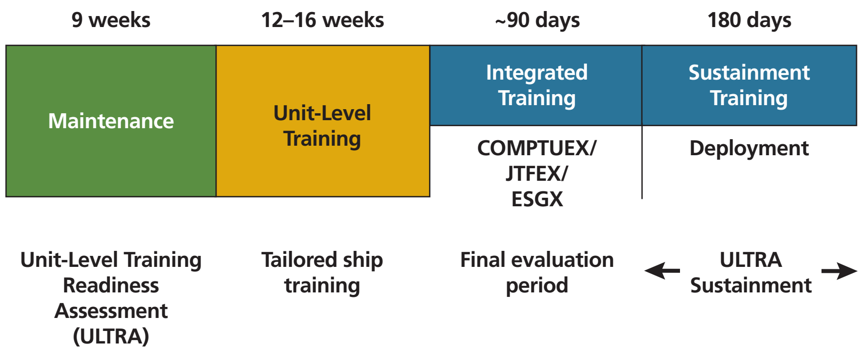
ULT is "between-the-lifelines" training for a ship. A ship's crew must be able to operate the ship in a safe and secure manner, perform assigned missions, and self-train. Ship crews undergo a ULT readiness assessment after a maintenance period, and crewmembers must be certified in each of their respective mission areas. They can be certified in one of two ways: during an initial ULT Readiness Assessment (ULTRA) if they meet performance standards, or after completing tailored training. Although a ship's crew gains an initial certification in ULT, training exercises for each mission area must be performed throughout all phases of training to sustain readiness.

ATGs are the training authorities that provide training support to ships during ULT. ATGs train and work directly with the ships and report to their respective TYCOMs—Naval Surface Forces, Pacific, and Naval Surface Forces, Atlantic. The responsibility for training ships in the integrated and sustainment phases falls under the auspice of the Numbered Fleet Commanders (i.e., Commander THIRD Fleet and Commander SECOND Fleet) and their respective Strike Force Training Group and Tactical Training Group.

The succession of training involves four phases: independent unit ready for tasking (RFT); maritime security surge (MSS); MCO–surge ready (MCO-SR); and MCO-ready (MCO-R). Each phase entails its own certifications. After ships achieve ULT certification in all mission areas, they are considered RFT and may be deployed to conduct independent operations as needed. Depending on how they are used, their employment may involve more risk because they have not received integrated or sustainment training. MSS units have completed ULT and received additional, focused training in the integrated aspects of surge missions. Ships that have successfully completed a composite training unit exercise (COMPTUEX) are MCO-SR. Ships that complete sustainment training through a joint task force exercise (JTFEX) or other means are MCO-R. MCO-R is the training goal for all deploying ships.

Figure 2.1 illustrates which events normally occur within a cycle, the sequence of those events, and the approximate number of

Figure 2.1
The Fleet Training Continuum



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days required for each event. The maintenance period is usually about nine weeks long, but can last longer. The operational cycle of readiness and training begins after a maintenance period. There is an increased emphasis on the ability of ships to maintain training readiness and certifications, and even when a ship is in a maintenance period, training is conducted and training readiness is evaluated. It is no longer considered accepted practice to start at a low level of readiness (whether due to personnel turnover, reduced emphasis on training during maintenance availabilities, or both) and then ramp up readiness in ULT. Rather, the current training approach requires ships to maintain a high, steady readiness level and keep certifications and training current.

Unit-Level Training

Notionally, ULT lasts approximately 16 weeks, although training authorities have indicated that the amount of time dedicated to ULT has declined to 13 weeks. ULT may be performed before or after maintenance availability. ULT focuses on completion of TYCOM ULT requirements, which consist of onboard and ashore team training; in-port and at-sea ULT exercises; and unit inspections, assessments,

certifications, and qualifications.[1] ULT commences with ULTRA-Certification/Engineering (ULTRA-C/E). Ships must be able to support underway training requirements to complete ULTRA-C/E. The ULTRA, normally done at the end of the maintenance period, determines the strengths and weaknesses in the ship's training organization, evaluates the performance of watch teams, and populates the training database. Ships must also maintain a watch station replacement plan that addresses who will replace existing watchstanders as they are rotated off the ship or to higher watch levels on the current ship.

In ULT, ship crews strive for certification in all mission areas and ships must demonstrate the ability to self-train in order to maintain proficiency in all mission areas. Ships that do not achieve certification during ULTRA-C/E undergo a final evaluation period (FEP), which is a final certification exercise, at the end of the ULT period. Training completed in ULT continues throughout the operational cycle; i.e., ships train and must continue to be able to navigate, fight fires, operate the engineering plant, and complete other between-the-lifelines training events.

Through periodic ULTRA-Sustainment (ULTRA-S) evaluations, ships are evaluated on their ability to maintain training readiness after the ULT period. Sustainment of unit-level skills through continuous training is the foundation on which higher sustained performance is based.[2] The yellow shading in Figure 2.1 indicates that the data and analysis presented in this book focus on the ULT done after maintenance but before the integrated training period.

Repetitive training exercises are important to the maintenance of operator and team qualifications and proficiency. To maintain essential skills and proficiency, the SURFTRAMAN identifies exercises, by mission area, that need to be continuously performed throughout the ship's operational employment. We identify these exercises in Appendix A. The FRP requires ships to maintain continuous proficiency and

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[1] Department of the Navy, COMNAVSURFORINST 3502.1C, "Surface Force Training Manual," January 1, 2006a.

[2] Department of the Navy, COMNAVSURFORINST 3502.1D, "Surface Force Training Manual," January 1, 2007.

readiness, and this is also accomplished through training and the performance of repetitive training exercises.

The ability of a ship's training teams to train the crew is key to maintaining training readiness throughout a cycle. Ship training teams must be organized and proficient in training, evaluating, and providing constructive feedback to improve watchstander performance. A crew must be trained before, during, and after a deployment. Ship training teams assess watch team performance and develop and execute training plans to maintain training currency and readiness.

Integrated and Sustainment Training

After a ship completes its ULT certification, it begins integrated and sustainment training and is operationally assigned to a numbered fleet commander. West Coast ships are assigned to Commander, Third Fleet (COMTHIRDFLT), and East Coast ships to Commander, Second Fleet (COMSECONDFLT). COMTHIRDFLT and COMSECONDFLT are responsible for training CSGs and ESGs and certifying them for deployment. While they are deployed, ships are reassigned to the appropriate overseas fleet commanders. Commanding officers remain responsible for their ship crew's training proficiency.

The goal of integrated training is to meld an individual ship's actions into coordinated strike group operations in a challenging operational environment characterized by multiwarfare conditions.[3] Integrated training prepares the ship for missions that will be performed during deployed operations. The major at-sea exercise in the integration phase is a COMPTUEX. During the COMPTUEX, ships demonstrate the core capabilities needed for deployed operations.

The sustainment phase starts after ships complete the integration phase, continues through deployment and postdeployment, and ends when the ship enters a depot maintenance period. Sustainment phase training exercises ships and staffs in multimission planning and execution, including the ability to interoperate effectively in a joint wartime

[3] *Multiwarfare* refers to the conduct of more than one warfare mission (e.g., a combination of air, surface, or subsurface engagements).

environment.[4] During the sustainment period, ships may be operationally employed and must maintain mission-area certifications and proficiency in all Navy mission-essential tasks that they may be required to perform. When a ship is not deployed but is in a sustainment period, it conducts in-port and underway training to sustain proficiency and meet training demands.

Discussions with fleet subject matter experts who conduct integrated and sustainment-level training indicated that training during the integrated and sustainment training phases is carefully planned. Training consists of a combination of (in-port) fleet synthetic training (FST) events, schoolhouse training, and underway events to meet training needs and prepare the ship and crew for deployment.

Fleet Synthetic Training Supports Deployment Workups

The amount of simulation used in training the surface combatant force has increased as simulation technology has improved. There are network capabilities that can connect communications and battle systems. The Navy has made greater use of simulation technology due to increased data transmission and display capability and higher overall connectivity and fidelity.[5] FST, which is an in-port training event for a ship's Combat Information Center (CIC) team, has been a key part of this increased use of simulation.

An FST-unit (FST-U)–level event is a single-unit exercise during which synthetic signals are sent to onboard systems to test watchstander responses and command and control procedures in response to generated targets or scenarios. FST events normally precede underway training and prepare CIC watch teams for underway operations. As ships progress through ULT to integrated and sustainment-level training, FST events become increasingly more complex. FST exercises prepare

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4 Department of the Navy, 2006a.

5 *Fidelity* refers to the accuracy of the representation when compared to the real world. Office of the Under Secretary of Defense (Acquisition and Technology), *Modeling and Simulation (M&S) Master Plan*, Washington, D.C., October 1995.

ship CIC teams for increasingly complex underway exercises by introducing multiship and multiwarfare exercises. FST exercises continue to precede underway events through the integrated and sustainment phases. FST events occur prior to COMPTUEX and JTFEX underway training periods.

The Challenge of Underway Training

Underway training is effective in honing the proficiency of the crew and its ability to operate with other ships. However, it poses a number of challenges that are discussed below.

Training Demands Are Dynamic

Integrated and sustainment training are carefully planned. The training plan to prepare for the deployed operations of CSGs and ESGs, however, requires consideration of the needs of training participants who will perform specific missions. This training depends on the training audience and destination. The training exercises of deploying units are planned at several conferences, including the following:

- Initial Planning Conference
- Mid Planning Conference
- Master Sequence Event List Scripting Conference
- Final Planning Conference.

The training that is conducted underway is dynamic and based on the following:

- the mission the units are expected to perform while deployed
- the deployment location
- conditions under which the mission will be performed
- the needs of the training audience
- the underway services and resources that are available (e.g., opposition force ships, duty oiler, target drones, and aircraft).

Strike group commanders work closely with the trainers at the Atlantic and Pacific Tactical Training Groups to identify deployed mission capabilities and needs and carefully script and evaluate in-port and underway training requirements.

Deployed Conditions Vary

Training deploying forces is challenging because those forces must be trained in conditions that mimic those they might encounter while deployed. These conditions vary in terms of environment (e.g., weather, sea state, and water depth), opposing forces (e.g., capability and number of land, air, and surface forces), law (e.g., rules of engagement and over-flight authorization), and type and amount of allied support, among others. Furthermore, the training requirements must be flexible. Ships, units, and crews must be trained in a way that allows them to become capable of adapting to and handling the conditions they might encounter during deployment. Deploying units must be adaptable because, although those units may have trained for a specific location and mission, political and military climates can change and deployment areas can be altered while those units are underway.

The Fleet Is Determining Where It Is Best to Demonstrate Navy Tactical Tasks—In Port or Underway

Navy tactical tasks (NTAs) are tasks that Navy units must be able to perform to support a combatant commander. NTAs are specifically developed for each strike group and depend on the group's particular mission and destination. Training officials stated that if more NTAs can be demonstrated synthetically, fewer will have to be demonstrated at sea. Conversely, if there is no opportunity to complete NTAs at sea, then more must be completed synthetically.

The fleet is closely examining the NTAs that are completed during COMPTUEX and JTFEX exercises as well as what can be accomplished via FST to determine whether more exercises can be done in port (thereby reducing underway training days). This assessment is a high priority and is being aggressively worked on at both Fleet Forces Command and Strike Force Training, Atlantic.

Some events are challenging to complete synthetically. Antisubmarine warfare (ASW) is one example. Because of limitations within the shipboard simulation capability for ASW, heavy reliance is placed on at-sea completion of integrated ship ASW training.[6]

Opposition Force Assets and Services Are Scarce and Expensive

There are many challenges associated with completing underway training at the integrated and sustainment levels. One is the limited availability of opposition force ships to operate with underway. Another is the need to carefully script the availability and use of target aircraft and drones and their associated ranges. Furthermore, environmental restrictions (such as those placed on the use of sonar) on live firing and other events may preclude the accomplishment of training in local operating areas. Other challenges include the costs associated with the use of target aircraft and drones and range safety protocols that must be carefully monitored to prevent interference from private or commercial air contacts and surface shipping.

Our Analysis Focuses on ULT Events

We have noted that underway training is challenging and costly. We have also noted that the Navy already uses FST as a way to train in port. Although FST events exercise the CIC team, are dynamic, and can be tailored to specific scenarios for different units, there are other areas and numerous training exercises that surface combatants must perform throughout the operational cycle to maintain readiness. The training readiness for these exercises degrades over time, and the events must be repeated (sometimes every three months) to maintain currency.

In the chapters that follow, we examine the number of underway days that ships use in ULT and the exercises that ships perform in ULT while underway. Believing that some of these training exercises

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[6] *Integrated ASW* refers to the detection, tracking, classification, and engagement of an enemy submarine by air, surface, and subsurface units.

could also be accomplished in port or through simulation, we begin our exploration of the exercises in the next chapter.

CHAPTER THREE

Underway Days and Underway Training at the Unit Level

In this chapter, we first describe how we calculated the number of ULT underway days for the DDG-51 ships. We then describe what training these ships must complete and which training exercises were done underway. Of these exercises, we determine which occur with the greatest frequency—if they could be done in port, they would offer the greatest potential savings.

How We Computed the Underway Days

To determine the number of underway days used for ULT, we used the WebSked data and built a database of the employment schedules of DDG-51–class ships from calendar year (CY) 2004 through CY 2006.[1] We assessed the employment terms and training location to determine the number of underway days that passed from the start of ULT to its end. Figure 3.1 shows the number of underway ULT days used by DDG-51–class ships.

We computed the number of underway days by counting the number that occurred between the start and end of ULT. ULT begins with either the Command Assessment of Readiness and Training (CART) II or an ULTRA and ends with a FEP. Although a ship may

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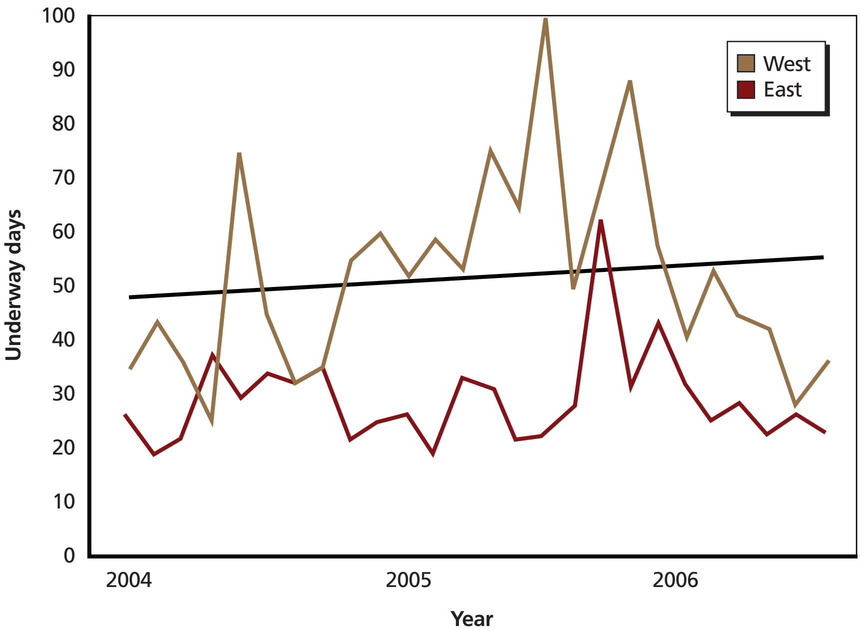
1 The WebSked database contains the operational schedules of ships and describes how the ships are employed during in-port and underway periods. These schedules allowed us to determine day by day whether a ship was underway or in port.

have been underway for reasons other than ULT during the ULT period, we counted all underway days from the start of the ULT to its end.

Our assessment of the data indicated that the number of East Coast ship underway ULT days typically varied between 20 and 40 days, with an average of 29 days. West Coast ships typically used more underway days (an average of 51 days), and their use of the days was more cyclical. The three days on which the highest number of underway days were used in ULT by three West Coast ships undergoing Combat Systems Ship Qualification Trials (CSSQTs) during the ULT period. These three ships used approximately 25 underway days to conduct CSSQTs. Our data reflects the total number of ULT underway days used to complete ULT for all DDG-51s, from CART II or ULTRA to completion of a FEP, regardless of their employment.

Figure 3.1
Number of Underway Days Used by East and West Coast DDG-51s to Complete ULT During CY 2004–2006



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Each of the last six West Coast ships to complete ULT in CY 2006 also appears in our database on one other occasion in the CY 2004–2006 timeframe; all the other West Coast ships make their first appearance in the database in CY 2006. Of the six West Coast ships that appear twice in the database, five of the ships used about the same number of underway days each time. The black lines across Figure 3.1 indicate the trends, by coast, in the number of underway days used for ULT during CY 2004–2006.

These data include 52 DDG-51–class ships that started and completed underway or in-port ULT in CY 2004, CY 2005, or CY 2006. Note that some ships started ULT in one calendar year and ended it in the next. Also, it is common for several ships to start ULT in the same month, and for no ships to start ULT in other months. Finally, note that the number of underway days used by West Coast DDG-51s was highest from May 2004 to August 2005. We were unable to identify any reason for this increase.

What Training Requirements Must Be Completed by DDG-51–Class Ships?

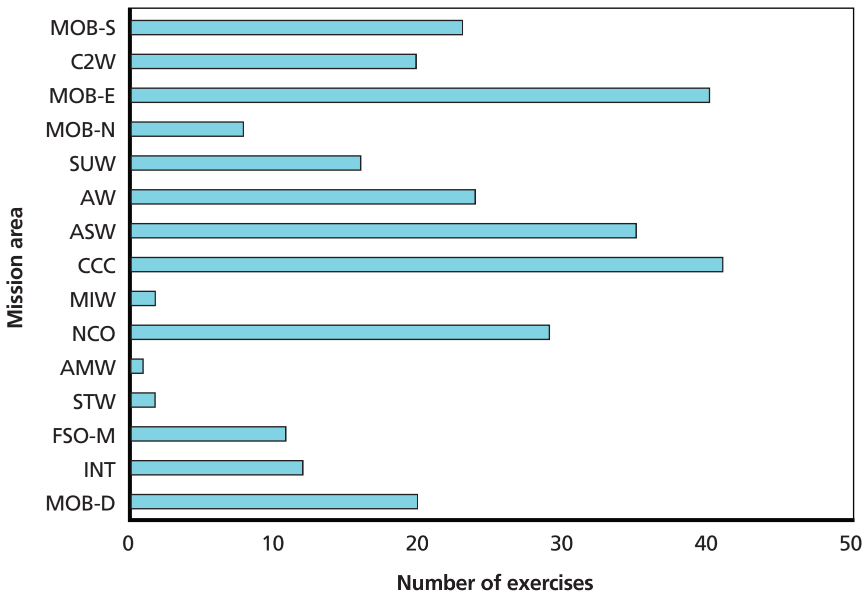
The SURFTRAMAN specifies the training requirements for surface combatants. The crews of DDG-51–class ships must be proficient in 15 mission areas. Each mission area has a variable number of exercises that a unit must complete satisfactorily to maintain its readiness. The mission areas for DDG-51–class ships are

1. mobility-seamanship (MOB-S)
2. mobility-engineering (MOB-E)
3. command and control warfare (C2W)
4. mobility-navigation (MOB-N)
5. surface warfare (SUW)
6. air warfare (AW)
7. antisubmarine warfare (ASW)
8. command, control, and communications (CCC)
9. mine warfare (MIW)

10. noncombat operations (NCO)
11. antimine warfare (AMW)
12. strike warfare (STW)
13. fleet support operations–medical (FSO-M)
14. intelligence (INT)
15. mobility–damage control (MOB-D).

The SURFTRAMAN also lists the repetitive exercises that ships must complete, at a specified frequency, throughout the Fleet Response Training Plan to maintain a training readiness rating for each mission area in the Status of Resources and Training System (SORTS).[2] Figure 3.2 shows the number of exercises, by mission area, that DDG-51–class ships must complete. The data were derived directly

Figure 3.2
Number of Exercises Required for a DDG-51–Class Ship, by Mission Area



SOURCE: Yardley et al., 2003.
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2 Department of the Navy, 2006a.

from the SURFTRAMAN. There are a total of 256 total exercises (see Appendix A for details).

The number of exercises varies by mission area. The CCC mission area contains the greatest number of exercises, followed closely by MOB-E. With knowledge of the mission-area exercises that ships must perform throughout the operational cycle, we next aimed to identify which exercises ships reported complete while the ships were underway for ULT. Our goals were to determine which exercises were completed underway and to identify a simulation capability that could potentially be used to complete the exercise in port via simulation. This substitution of simulation for underway training could reduce the underway time needed for training.

Which Exercises Were Completed Underway During Unit-Level Training?

To determine which training exercises were accomplished underway, our approach was first to identify the database that collects ship reports of training exercise completion and then to determine ship status (i.e., underway or in port) when each exercise was completed.

Ship training officers must report training exercise completion via a TYCOM Readiness Measurement System (TRMS) report. The TRMS database is a central repository for exercise completion data and is used for mission-area training readiness reporting.[3] We used the TRMS database to determine which exercises were reported by DDG-51–class ships, by date of exercise completion, during ULT. The database showed that a total of 20 DDG-51 ships had both started and completed ULT in CY 2004. Other ships were undergoing ULT, but

[3] The surface Navy is moving away from TRMS and toward the Training Operational Readiness Information System (TORIS)/Training Figure of Merit (TFOM) for readiness reporting. Although TRMS is still used for SORTS readiness reporting, ships now also report their readiness via TORIS/TFOM, which will be used when readiness reporting is transitioned to the Defense Readiness Reporting System. We used TRMS because it contained the best data available to us.

we only include those ships that started and completed ULT in CY 2004.

We then used ship employment schedules from the WebSked database to determine a ship's operational status by date. Employment schedules provided a chronological history of ship status by listing a ship's general location and describing (at a high level and via an "employment term") how the ship was employed at each location. We used the employment term and location of each ship to determine the ship's status (i.e., underway or in port) on any given day.

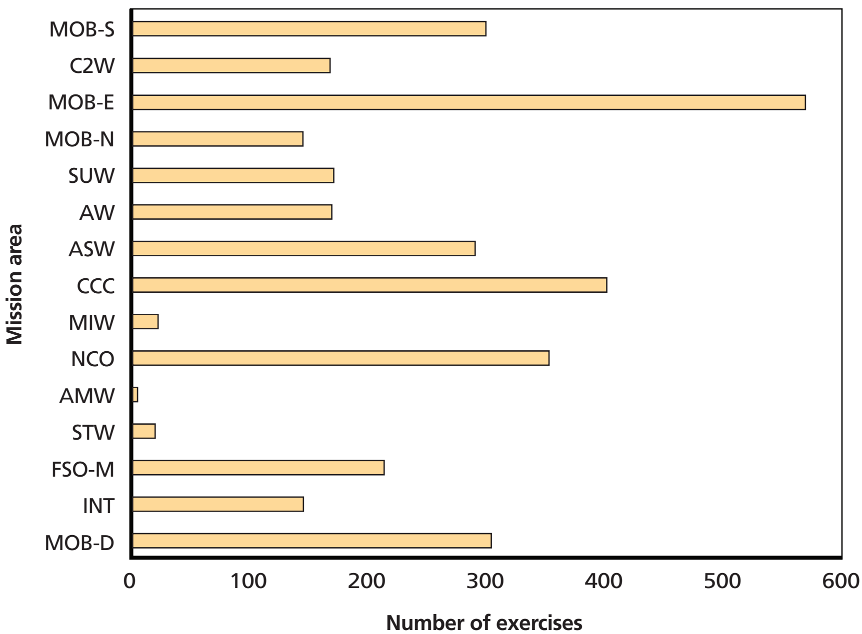
We then built our own database that combined TRMS data and the ship employment schedules. This database was used to determine an individual ship's status (i.e., underway or in port) when the ship reported completion of an exercise. We then linked the date that a ship reported an exercise complete to the ship's status on that date. This linkage allowed us to determine the number of exercises that were completed either in port or underway. We also used these data to identify exercises that are completed underway at a high rate.

Most Exercises in ULT Were Completed Underway

The data indicate that more than 70 percent of exercises in ULT were completed underway. The overall number of exercises completed underway varied by mission area and was roughly proportional to the number of exercises per mission area (see Figure 3.2). Figure 3.3 shows the aggregate number of exercises that were completed underway in ULT, by mission area, for the DDG-51s that both started and completed ULT in 2004. A total of 4,970 training exercises were reported complete by the DDG-51s, and over 70 percent (3,500) of these were completed underway.

Training officials at the ATGs and TYCOM indicated that the best way for a ship to complete training requirements is underway. There are a number of reasons for this. When a ship is underway, the commanding officer has a crew dedicated to its work, and fewer distractions arise than when a ship is in port. (While in port, a ship's crew must take on stores, maintain equipment, and attend to medical

Figure 3.3
Number of Exercises Completed Underway by DDG-51–Class Ships in ULT, by Mission Area, CY 2004



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and personal issues. These are necessary but time-consuming activities.) However, the Navy is reducing nondeployed underway time in FY 2008 from 24 days to 22 days. Because of this reduction, more time will be available in port, thus increasing the availability of crews to perform simulator-based training.

We considered the data presented in Figure 3.3 to be representative of exercises that are completed underway by DDG-51–class ships. It was important to identify exercises that are done underway in ULT because these exercises provide a basis on which to focus. Specifically, the data allowed us to determine which exercises are completed underway at a high rate. Based on our research and interviews with subject matter experts, we then determined where there is a simulation capability that could be used for those exercises that are most frequently completed underway. If a suitable simulation capability were available,

the mix of underway and in-port training could be changed without disrupting readiness.

Engineering Training Is a Major Driver of Underway Days in ULT

The data indicated that MOB-E exercises were the ones completed underway most often. Ships reported more than 600 MOB-E exercises complete while underway in ULT. Although the total number of all exercises completed underway by mission area was roughly proportional to the number of exercises per mission area, MOB-E exercises were an exception because they were completed at a higher rate in ULT. The number of MOB-E exercises completed is significant because each watch team must satisfactorily complete each engineering exercise. This means that a MOB-E exercise must be completed twice (at least once for each watch team—more often if the team was ineffective) before a TRMS exercise completion report for that exercise is submitted. Therefore, although 600 MOB-E exercise results were reported, 1,200 or more may have actually occurred. This is not the case for other mission-area training exercises, whose exercises are completed satisfactorily only once before they are reported.

The SURFTRAMAN scheduling guidance for completing MOB-E exercises takes into account the 50-percent demonstration standard.[4] This standard assumes, based on historical performance, that half of the exercises will not be done effectively the first time. Therefore, MOB-E exercises should be scheduled more often (i.e., at twice the rate) because only 50 percent of those exercises are likely to be graded as effective.

Training authorities report that engineering training is a major driver of underway days in ULT, and our data supports their state-

[4] This training guidance should not be confused with the standard for underway certification, which is also 50 percent. When a watch crew receives an external evaluation, the standard is that 50 percent of the tasks must be performed correctly for the team to be certified. Thus, if the watch team runs through a set of eight exercises, at least four must be done successfully. This is true for each set of exercises for each watch team evaluated.

ments. Training representatives at both the ATGs and TYCOM confirmed that the engineering certification is challenging, is a major driver of underway time in ULT, and represents a "half-ton gorilla" that must be tackled. An engineering certification does not consist only of satisfactory completion of engineering casualty control (ECC) drills, but drills are an essential part of the assessment. For a ship to receive an engineering certification, the minimum operational equipment must be achieved for underway operations; administrative programs must be satisfactory; the maintenance, safety, and operating parameters of equipment must be satisfactory; and the ship must demonstrate the capability to combat a "class bravo"[5] fire in the main engineering space.

We have described how much underway time is used by DDG-51–class ships and which exercises must be done to maintain mission area proficiency. We have also shown that of 4,970 exercises completed in 2004, 70 percent were completed underway. We quantitatively confirmed perceptions that engineering exercises are a major driver of underway time in ULT. We next examine which of these engineering exercises *must* be done underway.

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[5] A class bravo fire is a liquid (e.g., fuel, lubricating oil) fire.

CHAPTER FOUR

Which Exercises Must Be Done Underway and Which Could Be Done In Port

Our next step was to determine which exercises must really be done underway and which could be done in port. Previous RAND research indicates that many exercises do not in fact need to be done underway.[1] We used the assessments from our previous work, updated them with the current exercises used for readiness reporting by surface combatants, and forwarded the new assessment to Afloat Training Group, Pacific (ATGPAC), for its review. ATGPAC concurred with our assessment. The exercises that ships must perform fall into one of three categories:

- must be completed underway
- can be completed in port using an approved simulator (i.e., an authorized equivalency)
- can be completed in port and without a simulator.

Like Figure 3.2, Figure 4.1 shows the total number of exercises that DDG-51–class ships must complete by mission area. However, Figure 4.1 also indicates how many exercises in each mission area must be performed underway (blue), may be completed in port with a simulator (red), or can be completed in port without a simulator (yellow).

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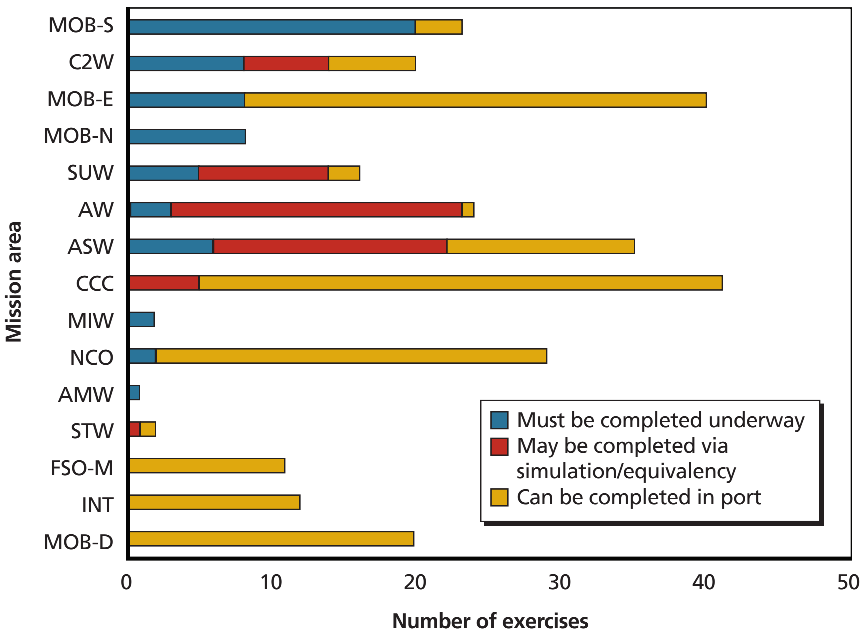
[1] In previous research, senior enlisted personnel from Commander, Surface Forces Atlantic, provided expert judgments about each individual exercise and where it could be completed. Exercises that must be completed underway consisted primarily of live firing, navigation, seamanship, and engineering exercises. See Yardley et al., 2003.

Figure 4.1
Number of Exercises Required for DDG-51–Class Ships, by Mission Area and Location



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As the figure demonstrates, the MOB-S and MOB-N mission areas contain the highest percentage of exercises that must be done underway. Seamanship exercises include replenishment at sea and getting underway from a pier or mooring. Navigation exercises include harbor transit, piloting by gyrocompass, and low-visibility piloting. These exercises require total ship integration and coordination—of the bridge, CIC, and engineering watch teams as well as special evolution teams (e.g., sea and anchor details, low-visibility details, and underway replenishment teams)—and are best done underway.

Currently, the SURFTRAMAN only authorizes simulation equivalency status (shaded in red) for warfare mission areas (i.e., C2W, SUW, AW, ASW, CCC, and STW). Many AW exercises can be simulated via embedded Aegis Combat System Training System, Battle Force Tactical Trainer, and other devices. Although a high per-

centage of ASW exercises can be simulated, the fidelity of the current simulator is insufficient to effectively perform the ASW exercises via simulation.[2]

Although the SURFTRAMAN currently authorizes equivalencies only for warfare mission areas, simulation technology has advanced and there are simulators for other, *non-warfare* mission areas. In Appendix B we discuss and provide details on an extensive survey of simulation technologies that are currently certified for use by the U.S. Navy, by the U.K. Royal Navy and other foreign navies, and by the commercial sector.

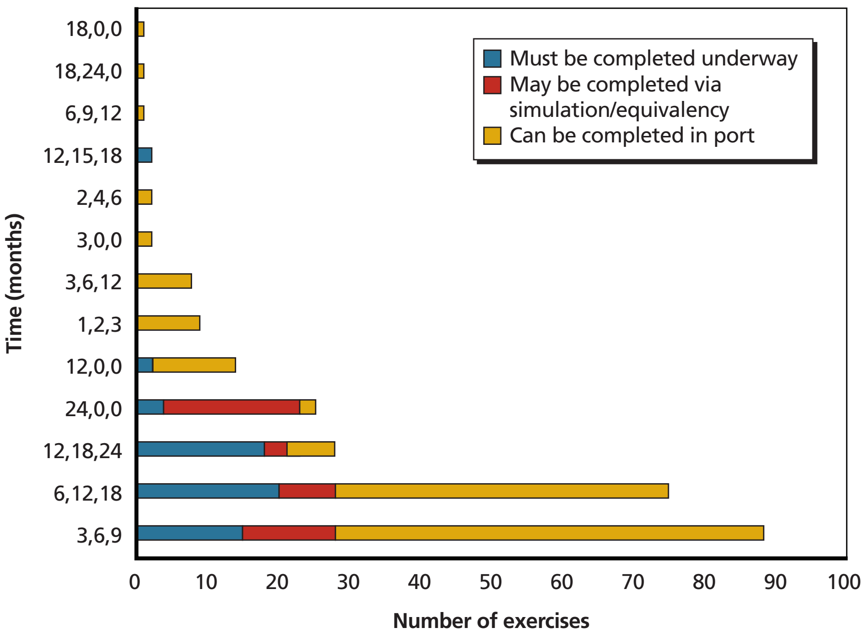
The Frequency of Exercises

We examined required exercises to determine how frequently they must be completed. Figure 4.2 shows the frequency (called "periodicity" in Navy training publications) of exercises that must be done by DDG-51–class ships while underway, in port via simulation, or in port without simulation. The numbers on the horizontal axis refer to the exercise periodicities required to maintain proficiency. For example, the far right column indicates that there are 88 exercises that must be done every three months (i.e., [3, 6, 9]) for the crew to maintain the highest proficiency level (M-1) for that exercise.[3] After three months, the proficiency for that exercise degrades to M-2; after six months, it degrades to M-3; and after nine months, to M-4. Some exercises are done infrequently. The bar label [18, 0, 0] means that the exercise must be done every 18 months to prevent exercise proficiency from degrading to M-4.

2 The ASW onboard trainer (OBT) is limited because it provides only a basic training capability for a new trainee and can only simulate a single engagement. Additionally, the ASW OBT does not provide adequate environmental conditions or background clutter and cannot adequately represent the shallow-water environment.

3 Mission-area readiness for training is determined by comparing the current level of training with the standards for a fully trained unit. M-1 represents the highest level of readiness that can be achieved; M-5 is the lowest.

Figure 4.2
Number of Exercises Required by DDG-51–Class Ships to Maintain Currency, by Periodicity and Location



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As Figure 4.2 demonstrates, the required frequency of exercises varies. Most exercises must be repeated every three or six months for the ship to maintain M-1 proficiency. Some exercises must be done on a yearly basis and then every six months thereafter (i.e., [12, 18, 24]).

Equivalencies are authorized at a high rate for infrequent exercises. Exercises that need to be completed just once every two years (i.e., [24, 0, 0]) contain the highest number of exercises that may be accomplished using equivalencies.

Exercises Completed Underway with the Highest Frequency

We then determined which mission-area exercises were completed underway with the highest frequency, because if these exercises could

be done in port (with or without simulation), then total ship underway days required could potentially be reduced. Those exercises that were completed underway at a high rate sometimes account for the need for ships to be underway for training. We found that engineering exercises were completed underway with the highest frequency.

We evaluated exercise periodicities to determine whether exercises that can only be done underway must be completed at a higher frequency than those that can be done in port. We determined the number of exercises, by location (i.e., underway, in port with simulation, or in port without simulation), that must be done over a two-year operational period. To do this, we multiplied the number of exercises in Figure 4.2 by the number of times they must be completed over a two-year period to maintain the highest level of readiness. We found that a total of 1,443 exercises must be completed for the ship to maintain the highest readiness (M-1) for each required exercise. However, over a two-year period, fewer than 20 percent of these exercises need to be done underway. This suggests that approximately 80 percent of required exercises over a two-year period can be completed in port.

Few Engineering Exercises Need to Be Done Underway, But Most Were

Much Engineering Training Can Be Done In Port

The Department of the Navy's "Engineering Department Organization and Regulations Manual" provides overall guidance on engineering training.[4] It states that engineering exercises containing both engineering evolutions and ECC drills should be practiced in port as well as underway. Nearly all evolution training requirements can be conducted in port and, particularly in the case of ships powered by gas turbine and diesel, almost all can be done with the plant in cold iron.[5]

4 Department of the Navy, COMNAVSURFORINST 3540.3, "Engineering Department Organization and Regulations Manual (EDORM)," August 11, 2003.

5 *Cold iron* refers to a ship's state where the engineering plant is shut down and the ship is drawing power from shore.

ECC exercises or evolutions should be conducted a minimum of two times a week.

The SURFTRAMAN lists 40 ECC exercises that must be repeated throughout the operational cycle to maintain proficiency. Most ECC exercises can be done in port; a few can only be done underway. Figure 4.3 illustrates the number of ECC exercises that were completed underway for 20 DDG-51–class ships in CY 2004. The ECCs are listed on the vertical axis and the frequency completed is on the horizontal axis. Exercises that can only be done underway are shaded red. Of the 39 exercises, only eight (21 percent) need to be done underway. Our analysis indicates that a total of 612 (77 percent) of ECC exercises were completed underway in ULT by the crews of the 20 DDG-51s.

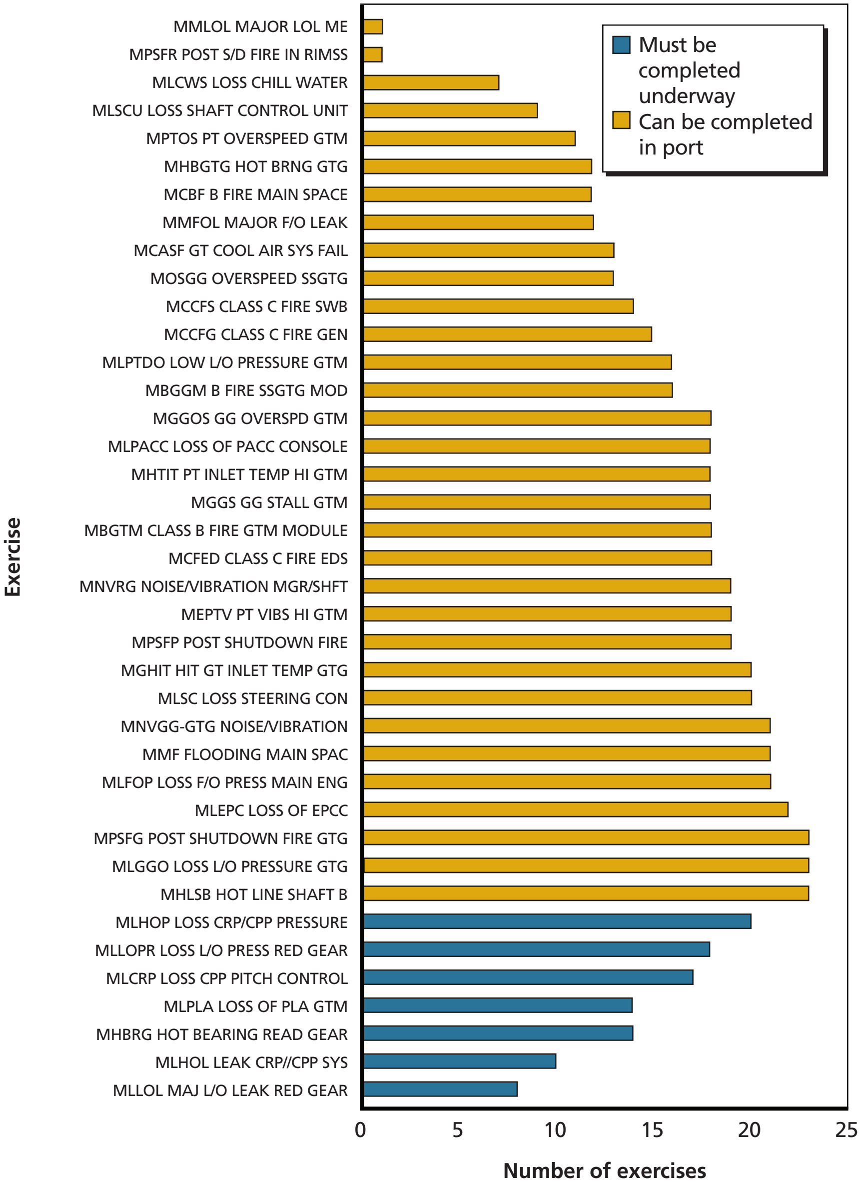
Training authorities report that up to 60 percent of underway days in ULT training is devoted to engineering training. The crews' need to develop proficiency in the performance of ECC drills is a major driver of underway days in ULT. ECC drills test the engineering watch team's ability to control the gas turbine propulsion engines, main reduction gear and shafting, electrical power plants, auxiliary machinery, damage-control equipment, and associated systems and equipment casualties.

Each qualified watch team is required to perform ECC exercises effectively. Individual watchstanders must memorize the controlling and immediate actions required to recover from the casualty. The SURFTRAMAN places ECC exercises in three categories:

- Category 1—nine quarterly drills, for a total of 36 per year
- Category 2—18 semiannual drills, for a total of 36 per year
- Category 3—13 annual drills, for a total of 13 per year.

Each watch team needs to perform 85 (36 + 36 + 13) drills annually. The average number of drills required per quarter for one watch team is approximately 21. There are normally three watch teams onboard a ship, so 21 drills per quarter per watch team multiplied by three watch teams results in 63 drills per quarter. As pointed out in the previous chapter, the SURFTRAMAN assumes an effectiveness standard of 50 percent for these drills. Therefore, the number of drills that

Figure 4.3
Number of MOB-E Exercises Completed Underway by DDG-51–Class Ships in UTL, CY 2004



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must be scheduled to achieve the 50-percent effectiveness standard per quarter per DDG-51–class ship is 126 (63 x 2).

Figure 4.3 addresses only ECC drills, but engineering evolutions are also performed and evaluated.[6]

Engineering Certification Requirements

Engineering training, assessment, and certification consists of

- training and assessment of evolutions and casualty control drills
- main-space fire doctrine training and certification
- monitoring material-condition supporting operations
- correcting management program discrepancies.[7]

During final certification training and assessment of evolutions and casualty control drills, two watch teams must achieve a combined average of 65-percent effectiveness at evolutions and 50-percent effectiveness at casualty control drill sets. In addition, management programs must be assessed as satisfactory and the crew must demonstrate the capability to effectively combat a class bravo fire in a main engineering space.

Engineering Drills Are Repetitive

The SURFTRAMAN states that to maintain training readiness engineering, category 1, 2, and 3 drills must be performed and evaluated as effective quarterly, semiannually, and annually (respectively). The requirement to perform 85 effective engineering drills per watch team per year can be time- and manpower-intensive. If some of these periodic requirements could be accomplished via simulation, underway training requirements could potentially be relieved. In addition, engineering watch teams could achieve improved proficiency when they do go to sea due to increased practice and repetition.

[6] There are 101 evolutions for a DDG-51–class ship. Evolutions include such actions as aligning, starting, and stopping ship equipment (including fuel oil, lube oil, chilled water, sea-water service, fire main, and other systems).

[7] Management programs consist of lube oil and fuel oil quality management, hearing conservation, etc.

The 50-percent effectiveness rate, which requires that only one out of every two ECC drills be effective, appears to be a low standard. Increased repetitions through simulation could potentially increase proficiency and make underway training more effective. Training provides proficiency, and, in general, performance increases with repetitions. With increased repetitions, performance generally increases rapidly at first and then continues to increase at a decreasing rate. If an exercise is not performed for a period of time, proficiency degrades; hence the need for repetitive training.

Summary

The result of our assessment of DDG-51 exercises that were done underway in ULT is presented in Table 4.1 along with the result of our assessment of which exercises can be done in port. The table shows what percentage of exercises can only be done underway, how many actually were done underway, and how many could be done in port (with or without simulation). The table breaks the data down first by all exercises and then by MOB-E exercises.

Some 76 percent of the DDG-51 exercises can be done in port either by hands-on training (no simulation required) or via simulation. Therefore, considerable potential exists to accomplish training that is now done underway by completing the exercises in port. Whether sim-

Table 4.1
Percentage of DDG-51 Exercises by Potential and Actual Location

Category	Percentage
Exercises that can only be completed underway	24
Exercises that were completed underway in ULT	70
Exercises that can be completed in port (with or without simulation)	76
MOB-E exercises that can only be done underway	21
MOB-E exercises done underway	77
MOB-E exercises that can be completed in port (with or without simulation)	79

ulators exist or could be developed to accomplish such training is the subject of subsequent chapters.

ECC drills are completed underway with high frequency, but most of them could be done in port. Furthermore, ECC drills are repetitive and must be done throughout a ship's operational cycle for the engineering watch team to maintain proficiency. The following chapter discusses a DDG-51 engineering simulator used at a U.S. Navy training command.

CHAPTER FIVE

Engineering Simulators Offer Opportunities for Increased Proficiency and a Potential Reduction in Underway Training

In previous chapters we identified which exercises could be done by simulation and which were done underway most frequently. This chapter describes a current Navy simulator that could be used to train members of the engineering watch. It also discusses several aspects of the use of simulators, including additional benefits, cost considerations, and drawbacks.

As Chapter Four indicates, engineering exercises are completed underway at a higher rate than any other exercise done in ULT. Surface training authorities espouse the use of simulators for training because they offer significant benefits. The Navy does have surface propulsion training devices and those are listed in Appendix C. Some of these simulators are located in and around fleet concentration areas (FCAs), but simulator use is not part of the training process and it occurs at the ship's discretion. Simulated practice for anticipated exercises improves execution of the actual event, and procedures exercised in port will be executed more smoothly at sea. Preparation for every operation should include the use of simulation and synthetic training systems.[1] We think that the DDG-51 engineering simulators used at the Surface Warfare Officer School (SWOS) in Newport, Rhode Island, offer an immediate opportunity to increase watchstander proficiency and potentially reduce underway days.

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1 Department of the Navy, 2006a, p. 348.

Our evaluation indicates that 31 MOB-E exercises could be done in port. Our data indicate that DDG-51–class ships accomplished over 600 of these MOB-E exercises underway in CY 2004. To do more MOB-E exercises in port with simulators, the simulators must be able to replicate the drills that would be done onboard, and the consoles should be similar to those used by DDG-51 engineers onboard their own ships.

The Navy's DDG-51 engineering simulator, which is available in the Navy inventory,[2] can be used to perform this MOB-E training. If the Navy used this simulator for MOB-E training by placing the simulator at the Norfolk, San Diego, and other FCAs, positive effects might result. If a process was developed to include engineering simulation training before an ULTRA-CE, watchstanders could go to sea with a higher level of proficiency. This in turn could lead to fewer underway days needed to achieve proficiency.

Another positive effect of utilizing an engineering simulator is that it could provide much-needed MOB-E exercise practice for engineers whose ships have not been underway for extensive periods due to shipyard availabilities. Furthermore, whereas the SWOS simulator only offers training for officers, a DDG-51 engineering simulator at the FCAs would offer opportunities for enlisted personnel to gain proficiency through repetition and practice of MOB-E exercises.

Surface Warfare Officer School Engineering Simulators

The simulator at SWOS is capable of providing training for eight of the nine category 1 drills, 14 of the 18 category 2 drills, and all 13 of the category 3 drills. Overall, the SWOS engineering simulator provides training for 35 out of 40 ECC drills.

The engineering class of instruction at SWOS uses a combination of classroom training, desktop trainers, and a DDG-51–class Gas Turbine Propulsion Plant Trainer (GTPPT), which is a replica of full-size

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[2] Naval Air Warfare Training Systems Division officials state that the components for a DDG-51 full-mission simulator are in their inventory.

consoles found in a DDG-51 central control station (CCS). The classroom training provides engineering theory and requisite knowledge of systems, temperature, and pressures as well as dependencies and interactions between systems and auxiliary equipment.

A Desktop Trainer and Full-Size Simulator Allows Hands-On Practice

The high-fidelity desktop trainer is used to orient the students to the consoles. The desktop trainer replicates the propulsion and auxiliary control console (PACC), the electric plant control console (EPCC), and the damage control console (DCC). Figure 5.1 shows a prospective engineer training at the desktop trainer. The student uses the trainer to align the plant for operations (i.e., to complete evolutions, such as aligning systems for operation, starting equipment, monitoring key parameters, and stopping systems). The student has the ability to dial in and

Figure 5.1
Prospective Engineer Training on Desktop Training Device at the Surface Warfare Officer School in Newport, R.I.

Photo courtesy of U.S. Navy.

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display operating pressures and temperatures and to examine the result of his or her actions on engineering-plant equipment. The simulator is high fidelity in that it responds to operator actions as would an actual engineering plant. Incorrect action can lead to cascading casualties, while correct action restores the plant to the operating conditions per the actions of the engineering officer of the watch (EOOW).

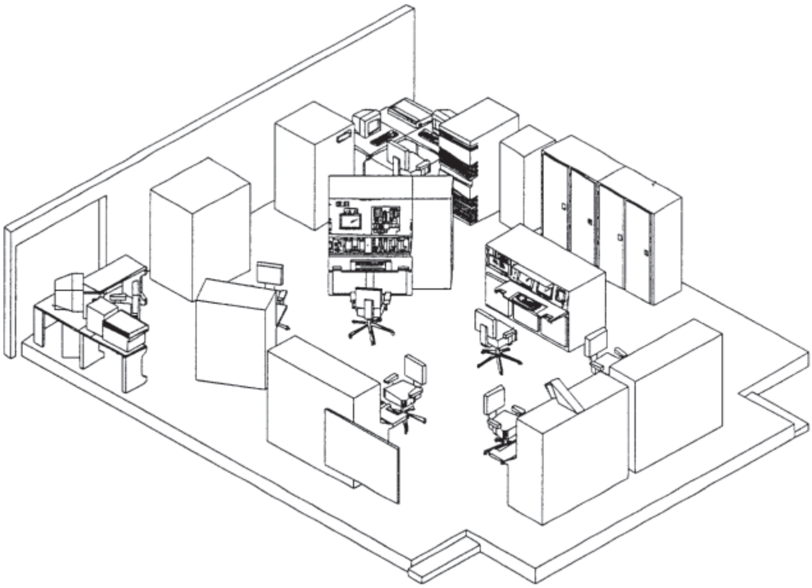
One limitation of this desktop trainer is its small size. The operator must use a computer mouse to navigate to all of the console displays. Therefore, the operation of the console is slower than that of a full mission simulator console.

After students achieve the required level of competency with the desktop training device, they proceed to full-size PACC, EPCC, and DCC console simulators. These simulators replicate the actual consoles found on DDG-51s. Students perform their drills—which range from checking master lights to aligning systems in preparation for underway operations to performing casualty control exercises—just as if they were on a DDG-51.

The DDG-51 GTPPT at SWOS simulates the DDG-51 Machinery Control System operation. Using full-scale simulated DDG-51 equipment, prospective engineering department heads and EOOW trainees are trained in normal and casualty operations in DDG-51 propulsion, electrical, and auxiliary systems. A digital central processing system controls the plant operations during normal and casualty-control operations. Training scenarios are initiated, controlled, and monitored from an instructor control position.

Casualties can be injected sequentially or simultaneously to evaluate a watchstander's performance. The consoles respond to the watchstander's actions in the same manner as an actual DDG-51 propulsion plant. When proper actions are taken to correct a casualty, the plant is restored from the simulated casualty. If incorrect actions are taken, the casualty can be removed only by the instructor. The instructor can also freeze the scenario to provide training instruction. Figure 5.2 shows the layout of the DDG-51 GTPPT at SWOS.

Figure 5.2
A DDG-51 GTPPT at SWOS



SOURCE: Naval Warfare Center Training Systems Division.
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The Performance of a DDG-51 Prospective Engineer Is Assessed on an Engineering Simulator by the ATG

Prospective engineering department heads and EOOWs are evaluated on their knowledge and actions at the end of their training. ATG, Atlantic, engineering trainers from Norfolk, Virginia, are flown to Newport, Rhode Island, to assess the prospective engineering department heads and EOOWs on plant operations and casualty control procedures. The students are evaluated against the same standard used onboard a DDG-51 during an ULTRA-E. ATG validates their knowledge and actions to the fleet standard on the simulator.

Engineering Watchstanders

An important factor in the decision to use a simulator in lieu of training underway is which crew members would benefit from the substitution. This section describes the composition of the engineering watch team and then discusses which members could benefit from simulator training.

The person in charge of the overall engineering watch team is the EOOW. The EOOW is responsible for the safe and proper operation of the ship's entire engineering plant and for the engineering watch team.[3] The EOOW stands watch in the CCS. Other CCS watchstanders are the PACC operator, the EPCC operator, and the DCC operator. The EOOW is supported by personnel who man the engine rooms, a sounding and security watch, and an oil-king assistant who draws fluid samples from engineering equipment.

The number of personnel on watch varies according to the conditions under which the ship is operating. A ship could be in cold iron, auxiliary steaming, or underway steaming condition III status.[4] Under condition III watches, the engineering watch team can be composed of up to nine watchstanders. This number can be reduced for specific stations by combining watchstander duties. The DDG-51–class engineering watchstander requirements are provided in Table 5.1.

A DDG-51 underway engineering watch can consist of a minimum of six watchstanders when some duties of individual watchstanders are combined. When duties are not combined, an engineering watch consists of nine watchstanders. The EOOW is in charge of the watch, and his duties may be combined as noted in Table 5.1.

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[3] Department of the Navy, 2003.

[4] Condition III is a peacetime steaming condition in which only essential underway watch stations are manned; weapons systems are not manned or ready and damage-control parties are not manned. Other readiness conditions a ship could be in include condition I—general quarters, which is the highest state of readiness. Other readiness conditions apply to specific situations.

Table 5.1
DDG-51–Class Engineering Watch Requirements and Watchstander Manning

	Watchstander Manning Required?		
Watch Station	**Cold Iron**	**Auxiliary Steaming**	**Condition III**
(1) EOOW	No	No	Yes
(2) PACC operator	No	No	Yes; can be combined with (1)[a]
(3) EPCC operator	No	No	Yes; can be combined with (1)[a]
(4) DCC operator	No	No	Yes; can be combined with (1)[a]
(5) CCS watch	Yes; can be stood down at CO discretion	Yes	No
(6) Engine room operator	No	No	Yes
(7) Propulsion system monitor	No	Yes	Yes
(8) Auxiliary system monitor	No	Yes; can be combined with (7)	Yes
(9) Sounding and security	Yes	Yes	Yes; can be combined with (8)
(10) Cold iron	Yes; can be combined with (9)	No	No
(11) Oil-king assistant	No	Yes; oil-king assistant required in duty section	Yes

SOURCE: Department of the Navy, 2003.

[a] The EOOW watch station cannot be combined with the EPCC operator and the PACC operator at the same time. If the EOOW acts as the EPCC operator, then a separate PACC operator is required. Likewise, if the EOOW acts as the PACC operator, then a separate EPCC operator is required.

Additional Reasons to Use Simulators for Engineering-Task Training

Although a major reason for using simulators to train ECC drills is the potential for reducing underway time, there are additional reasons. Simulators are inherently safer, they take less time to plan and use, and they allow situations or casualties to be introduced to the crew in a less artificial way.

Some Engineering Drills are Dangerous and Affect Other Systems. Some ECC drills can be performed more safely in a simulator. For example, ECC drills include electric-plant shutdown drills that can cause casualties to and otherwise affect shipboard electrical and electronic equipment and affect the mobility and safe operation of the ship at sea. Although it is necessary for watch teams to practice, perform, and recover from these types of drills, the performance of these drills in a simulated environment may prevent casualties and potentially be safer.

Planning, Organizing, and Executing ECC Drills is Time Consuming. It takes a lot of time to plan ECC drills on ship, position personnel, and communicate and coordinate. Planning and conducting training using engineering simulators is faster, easier, less manpower intensive, and potentially more effective than underway training.

A review of fleet training processes shows that it may take longer to plan a training situation or scenario than it does to conduct the actual training event itself.[5] In the case of ECC drills, the training team must first examine and determine the drills that the watchstanders must perform, consider the operational demands on the ship (which may limit the type or duration of drills), have the ECC drills approved by the commanding officer, and coordinate the drills with the ECC teams. Coordination includes assigning and rehearsing the actions during the drill with the ECC team, establishing communications and the locations of training team members, reviewing safety procedures with the watch teams currently on watch, conducting the drills, grading the drills, caucusing and discussing the performance of the drills, and debriefing the watch team on its performance. All in all, there is a

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[5] Drawn from Department of the Navy, *Initial Capabilities Document for the Total Ship Training Capability (TSTC)*, unclassified draft, December 10, 2006f.

significant amount of preparation, coordination, and communication required to conduct ECC drills, on the part of both the watch team and the training team.

Current Method of Cueing Casualties Is Artificial. During normal operation of a ship, engineering casualties are most often presented to the CCS watchstanders by a console alarm that provides an audio or visual signal to alert the operator. The operator is trained to recognize the casualty and affected equipment; use indicators to determine the associated equipment's operating pressure, temperature, and other conditions; and take immediate and controlling actions and communicate with space and other watchstanders.

During ECC drills, an example of a casualty initiation occurs when an Engineering Training Team (ETT) member imposes an engineering casualty in the form of a grease-pencil mark on a tank-level indicator to indicate an increase, decrease, or out-of-limit indication. Although this cueing is necessary to trigger the drill, the imposition of ECC drills is not as natural as actual drills, and the presence of an ETT member alerts the watchstander.

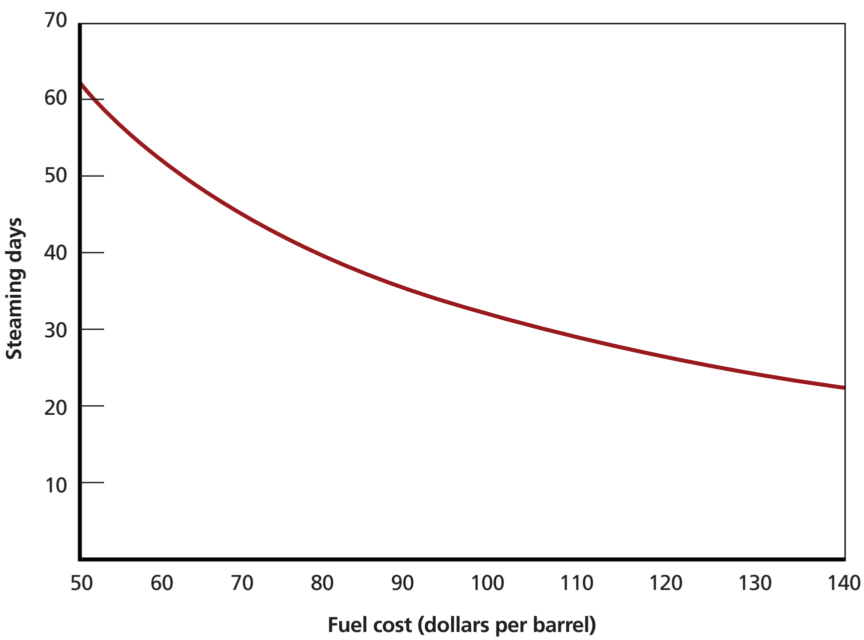
The ETT must be proficient in running the drills and continuing training throughout deployed operations. Watchstander and ETT knowledge is challenged and reinforced by conducting these drills underway. However, there is artificiality in the way that watchstanders are cued to specific casualties.

Both ETTs and watchstanders benefit from performing ECC drills in a simulator. The value to the ETTs is that selection of drills is menu driven. The value to the watchstander is that the time that the operator takes to perform initial and controlling actions is recorded, which allows the watchstander to receive objective feedback on results. Furthermore, the watchstander's performance and actions can be evaluated to a specified fleet standard. Finally, the fact that most drills can be performed on a simulator means that operational demands do not limit drill selection.

Cost of an Engineering Simulator

Simulators are expensive, but so is underway time. The estimated procurement cost of a full-size engineering simulator similar to the one located at SWOS is $1.6 million (not including sustainment costs). Given that fuel alone costs $40,000 or more per steaming day per DDG-51, it only takes a reduction of 40 steaming days to offset the simulator acquisition costs. (However, the cost of simulator sustainment and upgrades must also be considered.) With fuel prices on the rise, it would take even fewer days to offset the cost of simulator acquisition (see Figure 5.3). For example, if oil costs $90 per barrel, it would take a reduction of approximately 34 steaming days to offset the cost of procuring an engineering simulator. Moreover, such savings would occur every year, greatly increasing payback for the investment. Perfor-

Figure 5.3
Reduction in DDG-51 Steaming Days Required to Offset Simulator Acquisition Cost



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mance of ECC drills on a simulator also saves wear and tear on valuable equipment.

The DDG-51 engineering simulator just described exists only at SWOS, and none are located at the FCAs. However, our research indicates that there is a full-scale engineering simulator currently available within the Navy's inventory. This simulator could be placed at an FCA and used by ship crews who otherwise would not have access to it.

As the Navy projects its future for five, 10, and 20 years, a question arises: Will the Navy continue to conduct training the same way as in the past (i.e., underway), or could simulators provide a realistic opportunity to better prepare the surface combatant community to go to sea and make underway training more efficient in honing their skills? Simulation can and is used to develop, train, and prepare surface combatant crews for tactical missions. Moreover, simulation should be used wherever it can improve or enhance a capability, save money or resources, or reduce operational risk. The use of simulation supports increased knowledge and proficiency of individual and team skills, and training can be performed on a simulator in an effective manner. Increased use of simulators in non-tactical mission areas (e.g., engineering) that are major drivers of underway days could potentially save resources.

Drawbacks on the Use of Engineering Simulators

There are several drawbacks to using simulation for training. First, not all simulators are alike. For instance, some are realistic while others are not. Some simulators do not replicate what actually occurs during underway conditions (for example, simulators cannot accurately model the ASW environment). Second, some procedures are done differently on simulators than on actual ship equipment. For example, the desktop simulator requires the operator to use a computer mouse to scroll to different parts of the console display, whereas an *actual* console is totally visible to the operator. Third, resources are needed to keep simulators upgraded and current. Budget shortfalls traditionally result in slashed training budgets. A simulator's realism and usefulness declines if its configuration does not keep up with what is fielded in the fleet.

Finally, the simulator cannot be used to train the entire engineering watch team. An engineering watch team consists of CCS personnel (including the PACC, EPCC, and DCC operators and the EOOW), personnel who man the engine room and auxiliary spaces, a sounding and security watch, and the officer of the deck. The engineering simulator is used to train only CCS personnel in ECC procedures. Since the watch team members outside of CCS are not integrated into the simulator, the simulator can only be considered a part-team trainer. Research needs to be performed and methods need to be developed to incorporate the whole watch team into simulated events for engineering training.

A preferred method for training the whole team is the use of an embedded engineering trainer. In this method, the ship consoles are put into training mode. However, only the most newly-commissioned DDG-51s (i.e., DDG-97s and above) have this embedded capability. There is a plan to retrofit earlier DDGs (i.e., DDG-51s through DDG-96s) with this embedded engineering trainer though the Total Ship Training System (TSTS) upgrade, but this process is expensive and only two or three DDGs will be retrofit per year. Further research needs to be conducted to determine the costs and benefits of accelerating this retrofit process.

Summary

Engineering training is a major driver of underway time in ULT. Subject matter experts, data, and research confirm that the emphasis placed on training and certifying a DDG-51's engineering team is significant. ECC drills and evolutions must be performed and repeated by each watch team throughout the operational cycle to maintain currency. However, because existing simulators can be used to practice engineering exercises, underway days could potentially be saved if more drills were preformed in a simulated environment or in port.

The Navy does have a simulator in its inventory that can be used to perform some MOB-E training. This simulator is similar to the one at the SWOS in Newport, Rhode Island, and is capable of providing

training for eight of nine category 1 drills, 14 of 18 category 2 drills, and all 13 category 3 drills. Overall, this engineering simulator provides training for 35 of 40 ECC drills. The Navy should consider purchasing more of these simulators, placing them at FCAs, and developing a training process that allows ship crews to use them.

A simulator could increase the proficiency of watchstanders through increased repetitions. Training watchstanders in port through simulation and subsequently validating their performance, knowledge, skills, and abilities in conducting these events underway could ultimately make underway days more efficient. To capitalize on this potential, the Navy must invest in engineering simulators, trials, and incentives for ships to adopt the use of simulation for training.

CHAPTER SIX

Additional High-Frequency Exercises that Can Be Done In Port

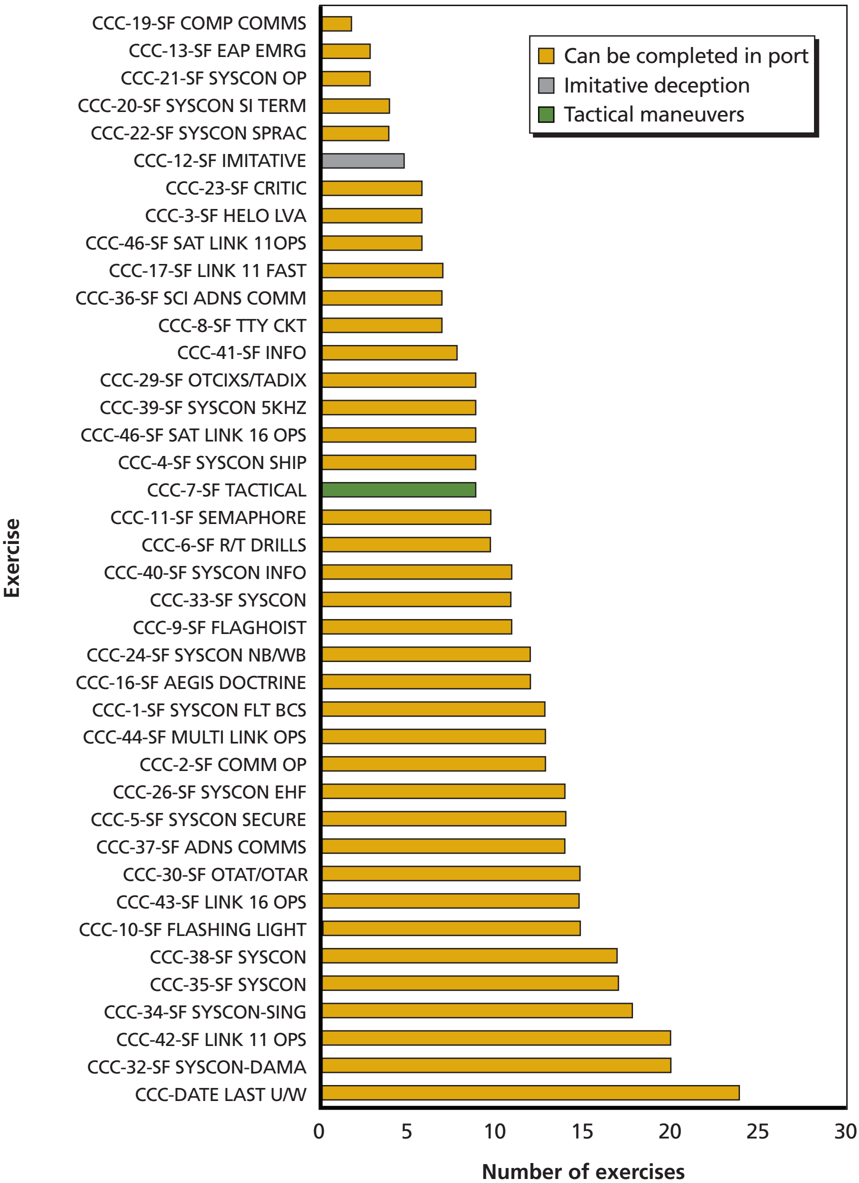
We also examined non–MOB-E exercises that are currently done underway but can be completed in port. These exercises fall in the CCC, NCO, MOB-D, and FSO-M mission areas. CCC exercises demonstrate proficiency in establishing and maintaining communications. NCO exercises include electronic equipment casualty control as well as shipboard force-protection measures. MOB-D drills exercise the crew's ability to combat fire, flooding, and other casualties and to restore the ship. FSO-M exercises train the crew in performing a full range of first aid, personnel transport, and battle-dressing procedures.

Each of these four mission areas contains a number of exercises that are currently done underway at a high frequency but can be done in port. We do not know if units completed these exercises underway because the ships already were underway (i.e., the exercises were performed as the opportunity arose) or if the ships got underway specifically to complete them.

In this chapter we examine these high-frequency exercises and compare them to our ATG-approved assessment of where the exercises need to be completed (i.e., underway or in port).

Figure 6.1 illustrates the number of CCC exercises that were completed underway in ULT in CY 2004. Our assessment indicates that only two CCC exercises must be done underway: CCC-12-SF (imitative deception) and CCC-7-SF (tactical maneuvers). We think that the remainder of the CCC exercises were completed underway purely because the ship already was underway. Indeed, simply powering up a

Figure 6.1
Number of CCC Exercises Completed Underway by DDG-51–Class Ships in ULT, CY 2004



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communications suite for underway operations completes many CCC exercises.

Figure 6.2 shows how many NCO exercises were done underway in ULT in CY 2004. Again, the rate of underway completion is high, especially since our research and assessment indicate that only a small fraction of these exercises (in fact, just two) must be done underway: NCO-33-SF (small-boat attack) and NCO-38-SF (VBSS).

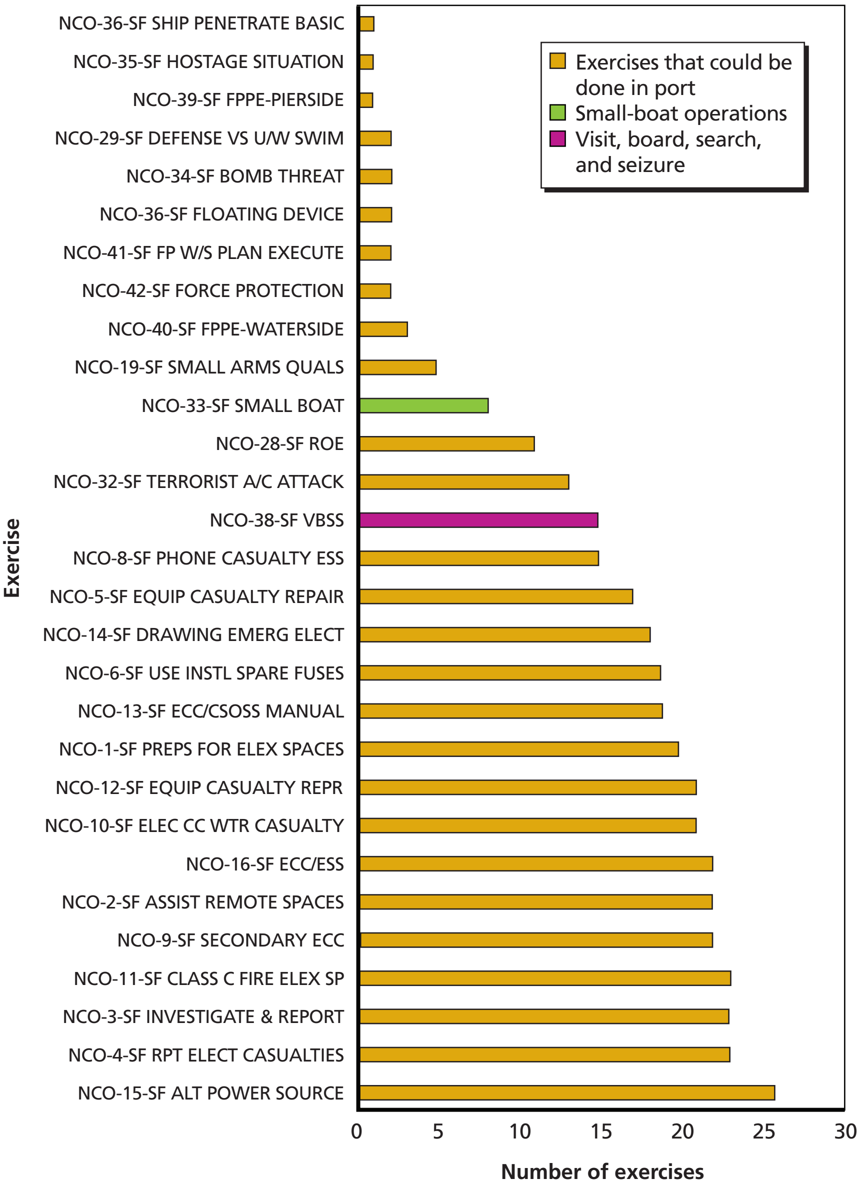
Some events must be done underway to fully practice and demonstrate the capability needed to support deployed operations, and VBSS is a good example. VBSS operations require a ship to launch a small boat with trained, armed sailors to board and inspect the cargo of vessels in a challenging underway environment. Figure 6.3 illustrates a VBSS team en route to board a vessel. VBSS operations involve a large portion of the ship's teams, including the bridge, deck crew, engineers, small-arms teams, helicopter (if embarked), and the VBSS team. Much integration and coordination is required, and ship teams must be proficient in these dynamic operations.

Some events do not have to be done underway. Figure 6.4 demonstrates that although every MOB-D exercise can be done in port, many were completed at high frequency underway in ULT in CY 2004.

Damage-control exercises include such events as combating fires, controlling flooding, and performing battle-damage repairs. Ship crews must be proficient in damage-control procedures, and every crewmember is required to qualify in basic damage control. Ships can practice the most-advanced damage control drills in port, including combating a main-space fire. Figure 6.5 is illustrative of onboard damage-control training, all of which can be done in port.

There are many reasons why these and other exercises are completed underway. Surface ships are built to be at sea, and there is a culture and training structure built to meet these training demands underway. We posit that all surface combatant commanding officers would say that the best place to train and evaluate crew competency is underway. In addition to these factors, training time in port must compete with other demands—maintenance, the loading of stores, equipment upgrades, and sailor family and personal obligations. A commanding officer who trains the crew underway, however, has full

Figure 6.2
Number of NCO Exercises Completed Underway by DDG-51–Class Ships in ULT, CY 2004



RAND *MG765-6.2*

Figure 6.3
VBSS Team Operations

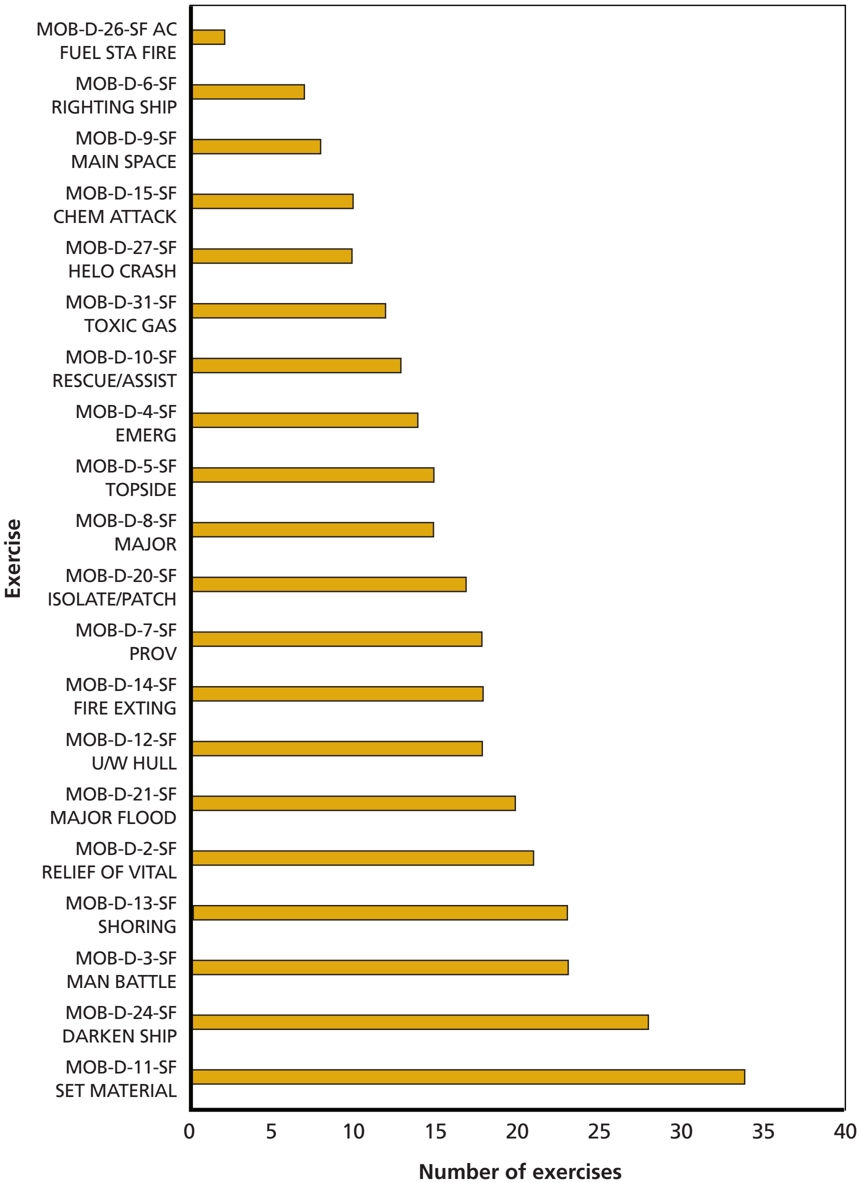
SOURCE: Mass Communication Specialist 3rd Class David Wyscaver (Released), U.S. Navy.
RAND *MG765-6.3*

control over how the crew is used. The crewmembers are in a captive environment and able focus on training objectives 24 hours per day. The underway environment also best replicates the deployed conditions under which the ship will operate.

Like MOB-D exercises, all FSO-M exercises can be completed in port. As Figure 6.6 shows, however, many medical exercises were done underway in ULT in CY 2004. Ships do not get underway just to perform medical exercises, but being underway offers an excellent opportunity to complete them.

Figure 6.7 illustrates the total number of exercises by mission area completed underway by ships that started and completed ULT in CY 2004. The mission areas are ordered from lowest to highest number of exercises completed underway. Red bars highlight the mission areas

Figure 6.4
Number of MOB-D Exercises Completed Underway by DDG-51–Class Ships in ULT, CY 2004



RAND *MG765-6.4*

Figure 6.5
Damage-Control Drills

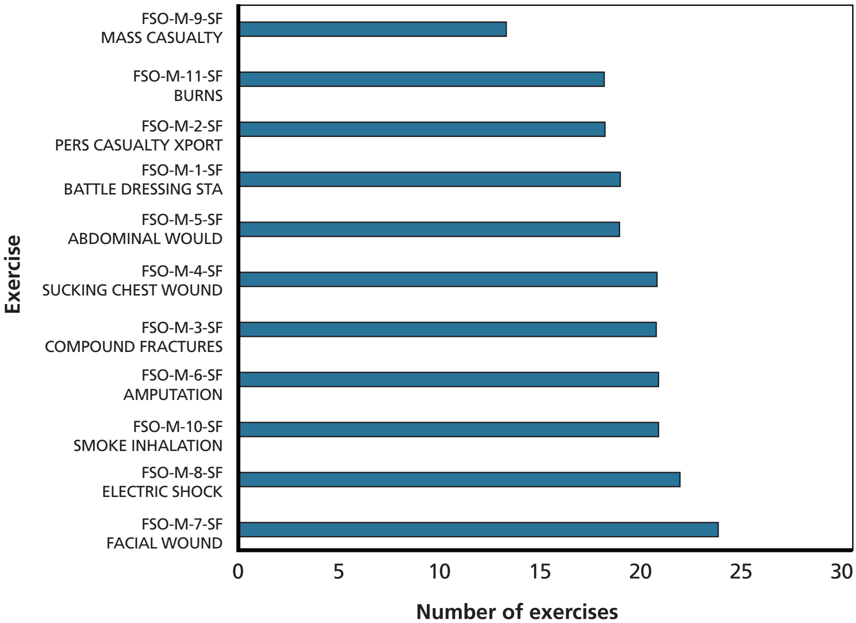
SOURCE: Mass Communication Specialist 2nd Class Byron C. Linder (Released)
U.S. Navy.
RAND *MG765-6.5*

whose exercises were done underway at a high frequency but can be done in port.

Summary of Exercises Done Underway

Our analysis clearly indicates that most ULT is completed underway even though many exercises can be done in port. We suspect that two factors heavily influence decisions to train underway. First, senior officers strongly believe that the best way to train for underway operations is to be underway. This belief is a product of culture and structure. Second, ships are sometimes already underway, and thus commanders seize the opportunity to complete as many exercises as possible in the underway environment.

Figure 6.6
Number of FSO-M Exercises Completed Underway by DDG-51–Class Ships in ULT, CY 2004



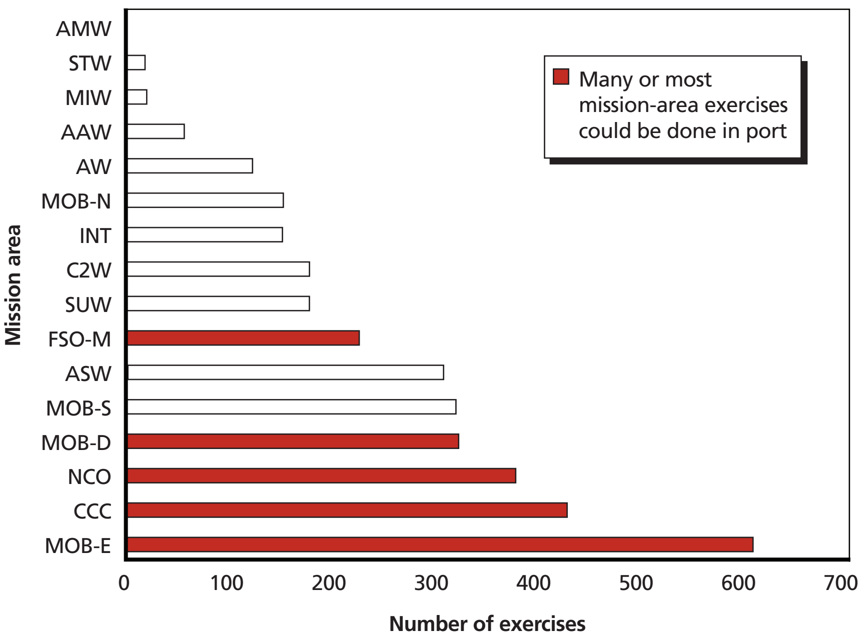
RAND *MG765-6.6*

Training exercises are performed, however, in an increasingly resource-limited environment. Thus, a balance between consuming underway resources (especially fuel) and meeting readiness demands must be achieved. A holistic approach that weighs *all* training demands against the time necessary to complete them is needed. A reduction in the major drivers of underway time should not reduce underway time to a level that negatively affects other training requirements.

Training authorities note that when a ship gets underway, its time is not its own. Other demands placed on an underway ship in a local operating area include serving as an opposition force ship for a deploying strike group, performing deck-landing qualification (DLQ) for helicopter squadrons, and serving as an assist or target ship for other units. Although these support services do provide training value to the ship, they tend to drive a ship's schedule. That is, if a ship is scheduled

to provide DLQs for a helicopter squadron, then that tasking precludes the ship from performing other training events that may be necessary for its readiness. Because this type of service-ship tasking takes precedence in the employment of surface ships, ships must fit their own training demands around this higher-priority tasking.

Figure 6.7
Exercises Completed by DDG-51–Class Ships in ULT, CY 2004



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CHAPTER SEVEN

Findings and Recommendations

Findings

We found that more than 70 percent of all DDG-51–class ship exercises (i.e., 3,500 out of a total 4,970) were completed underway in ULT in CY 2004. Engineering training exercises were completed underway with the highest frequency compared with the other 14 mission areas. In fact, training authorities report that up to 60 percent of underway time in ULT can be devoted to engineering training. TYCOM and ATG training experts assert that achieving engineering certification is a demanding challenge and a major driver of underway days, and that ECC-drill proficiency is part of that challenge. ECC drills are performed at a high rate underway; relatively few are completed in port.

We found that the SWOS engineering simulator trains engineering watchstanders on the same ECC drills that are performed underway. Moreover, ATG assesses the prospective engineers in their drill performance on these simulators, suggesting that the use of the simulator for ECC drills is valid.

We conclude that 35 of 40 ECC exercises could be conducted at a simulator training facility using a simulator similar to the one at SWOS. Through this engineering simulator, watchstanders could gain a higher level of initial proficiency in ECC drills before getting underway for training. They could also regain proficiency during extended in-port periods. This higher level of watchstander proficiency gained through simulators could reduce the number of underway days required

for training. A more detailed analysis is required to determine specific costs and benefits.

DDG-51 engineering simulators are available now. According to Naval Air Warfare Center Training Systems Division officials who coordinated the acquisition and maintenance of the SWOS DDG-51 engineering simulator, similar DDG-51 engineering simulators are available within the Navy's acquisition channels. Such a simulator would cost approximately $1.6 million (excluding sustainment costs). Because fuel costs alone are $40,000 plus per steaming day per DDG-51 when oil is $70 per barrel, it takes only a reduction of 40 steaming days to offset the simulator acquisition costs. As fuel costs increase, the number of underway days needed to offset the acquisition costs will decrease. Furthermore, our discussions with private contractors who provide the shipping industry with civilian maritime engineering simulators indicate that there is a robust capability to build an engineering simulator to respond to a demand.

A ship profits from having an embedded engineering capability that allows a crew's engineering teams to conduct MOB-E exercises on their own consoles. However, the installations that retrofit ships with these consoles are being funded in small increments—only two or three DDG-51–class ships per year. Because watchstander proficiency must be increased before ships go to sea, however, the Navy cannot afford to wait while the embedded training devices are installed.

Other demands are placed on a ship that is underway in a local operating area. These demands include performing services such as serving as an opposition force ship for a deploying strike group, performing DLQ for helicopter squadrons, and serving as an assist or target ship for other units. Although these support services do provide training value to the ship, they can also drive a ship's schedule. Ships must fit their own training demands around this higher-priority tasking.

Our research also shows that repetitive exercises must be done throughout a ship's operational cycle to maintain training currency. In concert with underway training, an engineering simulator would provide a useful vehicle for watchstanders to perform repetitive training requirements. Further research is necessary to determine the merits

and feasibility of the efficient use of simulation and underway days for engineering proficiency.

Recommendations

The Navy should invest in shore-based DDG-51 engineering simulators and place them at FCAs. Currently, the DDG-51 engineering simulator is only used at SWOS to train the prospective engineering department heads and department officers of DDG-51–class ships. However, wider use of the engineering simulators at FCAs by a greater number of DDG-51 engineers could potentially increase watchstander proficiency in the performance of ECC drills. Increased repetitions by engineering watchstanders (i.e., EOOWs and PACC, EPCC, and DCC operators) on an engineering simulator in port have the potential to increase proficiency through practice. When ships do get underway, the watchstanders could potentially be more proficient due to previous practice of the actions needed to conform to the Engineering Operational Sequencing System and the ECC procedures to stabilize, control, and recover from casualties that occur in the DDG-51 engineering plant.

To reduce underway training days, the Navy should direct that exercises that *can* be done in port *must* be done in port. To reduce underway training demands, ships should prioritize underway training time to complete those events that can only be done underway.

The Navy should also consider accelerating the upgrade that provides DDG-51–class ships with an embedded engineering training capability that allows training to be performed onboard on the ship's own equipment. The Navy is retrofitting DDG-51–class ships with this capability through TSTS upgrades, but these installations are proceeding at a slow pace. Accelerating the installation rate would provide more ships with an embedded training capability sooner and allow more training to be done in port on ship's equipment. These measures could produce cost savings, but the costs, benefits, and feasibility of this approach need to be evaluated.

The Way Ahead

Due to a concerted effort to reduce the time it takes to achieve surface ship unit-level warfighting proficiency, underway time has been reduced from 16 weeks to 13 weeks. Commander, Naval Surface Force's long-term goal is to achieve a continuous certification process and reduce biennial certification to two to three weeks.[1] Our research explored opportunities where the surface combatant community could potentially reduce underway training through the use of simulation and focuses on major drivers of underway training. Our research supports the "train in port, validate at sea" tenet. The Navy's surface community could potentially use simulation to better prepare crews for underway engineering training and thereby make underway time more efficient. Even without investment in simulators, the Navy could do more training in port if it directs commanders to complete exercises in port that can be done in port.

1 Etnyre, 2007.

APPENDIX A

List of Surface Exercises Required for Surface Combatants

This appendix shows the MOB-E exercises and evolutions required for engineering proficiency training for DDG-51–class ships (see Table A.1 and the list of evolutions that follows). It also shows other mission-area exercises that must be done to sustain readiness in DDG-51–class ships (see Table A.2).

Table A.1
MOB-E Exercises

Exercises	Validations
Main Engine Drill Family–Category 1 Drills (Quarterly, Core)	
MMFOL—major fuel oil leak	None
MBGTM—class bravo fire in GTM	None
Main Engine Drill Family–Category 2 Drills (Semiannually, Elective)	
MLFOP—loss of fuel oil pressure	None
MGGS—gas generator stall in GTM	MLPTO, MEPTV, MGGOSMHTIT, MLPLAMPTOS
MECUF—executive control unit failure	None
MLPACC—loss of propulsion and auxiliary control console	MLSCU
MLSCU—loss of shaft control unit	MLPACC
Main Engine Drill Family—Category 3 Drills (Annually)	

Table A.1—Continued

Exercises	Validations
MCASF—gas turbine cool air system failure	None
MLPTO—low lube-oil pressure in GTM	MGGS, MEPTV, MGGOSMHTIT, MLPLAMPTOS
MEPTV—power turbine vibrations high in GTM	MGGS, MLPTO, MGGOSMHTIT, MLPLAMPTOS
MGGOS—gas generator overspeed in GTM	MGGS, MLPTO, MEPTVMHTIT, MLPLAMPTOS
MHTIT—power turbine inlet temperature high in GTM	MGGS, MLPTO, MEPTVMGGOS, MLPLAMPTOS
MLPLA—loss of PLA in GTM	MGGS, MLPTO, MEPTVMGGOS, MHTITMPTOS
MPTOS—power turbine overspeed in GTM	MGGS, MLPTO, MEPTVMGGOS, MHTITMLPLA
MPSFP—post shutdown fire in GTM	None
Propulsion Drive Train Family–Category 1 Drills (Quarterly, Core)	
MLLOPR—loss of lube-oil pressure in main reduction gear	None
MHBRG—hot bearing red gear	MHLSB, MHST, MNVRG
Propulsion Drive Train Family—Category 2 Drills (Semiannually, Elective)	
MLCRP—loss of pitch control	None
MLHOL—major leak of CRP/CPP system	MLLOL
MLLOL—major lube oil leak in main reduction gear	MLHOL
MNVRG—noise/vibration in main reduction gear/shaft	HBRG, MHST, HLSB
MHLSB—hot line shaft bearing	MHBRG, MHST, MNVRG
MLHOP—loss of CRP/CPP pressure	None

Table A.1—Continued

Exercises	Validations
Propulsion Drive Train Family—Category 3 Drills (Annually)	
MHST—high shaft torque	None
Electrical Family–Category 1 Drills (Quarterly, Core)	
MOSGG—overspeed GTG	None
MBGGM—class bravo fire in GTG module	None
Electrical Family—Category 2 Drills (Semiannually, Elective)	
MHBGTG—hot bearing GTG	MNVGG, MGHIT, MLGGO
MGHIT—high gas turbine inlet temperature GTG	MHBGTG, MNVG, MLGGO
MLGGO—loss lube oil pressure GTG	MHBGTG, MNVG, MHIT
MPSFG—post shutdown fire GTG	MPSFR
MPSFR—post shut down fire in engine	MPSFG
MCCFG—class charlie fire generator	None
Electrical Family—Category 3 Drills (Annually)	
MLEPC—loss of EPCC (MLMCS—loss of control console in smart ship)	None
MFZDB—electrical fault on zonal main bus	None
MNVGG—unusual noise/vibration in GTG	MHBGTG, MGHIT, MLGGO
Integrated Family—Category 1 Drills (Quarterly, Core)	
MCBF—class bravo fire in main space	None
MCFED—class charlie fire in electrical distribution system	None
MMF—flooding in main space	None
Integrated Family—Category 2 Drills (Semiannually, Elective)	
MCCFS—class charlie fire in switchboard	None

Table A.1—Continued

Exercises	Validations
MLSC—loss of steering control	None
Integrated Family—Category 3 Drills (Annually)	
MLCWS—loss of chill water	None

The following MOB-E evolutions must be performed by the designated DDG-51–class engineering watchstanders at the specified intervals:

- EOOW routine evolutions (quarterly, core)
  - Don EEBD
  - Evaluate heat stress survey
  - Evaluate tag-out sheet
  - Evaluate lube oil sample
  - Evaluate fuel oil sample
  - Review operating logs
  - Start/stop firepump
- PACC/PCC routine evolutions (quarterly, core)
  - Don EEBD
  - Transfer control between PACC/PCC, PLCC SCU, and LOP
  - Transfer control between PACC/PCC and SCC
  - Shift fuel oil pumps
  - Shift lube oil pumps
  - Motor GTM
  - Start GTM
  - Stop GTM
  - Test console alarms
  - Start/stop sea-water service pump
- EPCC routine evolutions (quarterly, core)
  - Don EEBD
  - Start/parallel GTG/SSDG
  - Parallel bus to bus
  - Remove load/stop GTG/SSDG
  - Test EPCC alarms

- Engine room routine evolutions (quarterly, core)
  - Don EEBD
  - Align main reduction gear lube oil cooler
  - Shift lube oil strainers/filters
  - Shift purifier suction
  - Align/operate/secure eductor
  - Verify/align GTG for standby
  - Draw lube oil/CPP/purifier efficiency sample
  - Draw lube oil cooler waterside sample
  - Shift low pressure air compressor mode
  - Verify alignment stern tube cooling
  - Align/start/operate/secure oily waste transfer pump
  - Align/start HPAC
  - Align/start L/O purifier
  - Test SCU/PLCC/PLC alarms and indications
- Engine room infrequent evolutions (annually, elective)
  - Verify/align GTM fuel oil system
  - Verify/align GTG support systems
  - Verify/align fire pump
  - Shift lube oil pumps
  - Start GTM
  - Stop GTM
  - Motor GTM
  - Start GTG
  - Motor GTG
  - Shift fuel oil service pumps
  - Fuel purge GTM
  - Start/stop fire pump
  - Start/stop sea water service pump
  - Align/secure anti-icing
- Auxiliary equipment routine evolutions (quarterly, core)
  - Don EEBD
  - Align/operate/secure eductor
  - Draw lube oil sample
  - Align/start evaporator
  - Align/start high pressure air compressor

  - Sample/test potable water
  - Align freshwater tank to fill
  - Verify alignment stern tube cooling
  - Align/start/stop air conditioning plant
- Auxiliary equipment infrequent evolutions (annually, elective)
  - Start/stop fire pump
  - Verify/align fire pump
  - Start/stop sea water service pump
- Oil lab routine evolutions (quarterly, core)
  - Don EEBD
  - Draw coalescer outlet/bottom sample
  - Draw prior to start sample on service/auxiliary service tank
  - Conduct contaminated fuel detector/free water detector
  - Align/operate/secure oily water separator
  - Transfer fuel oil storage to service
  - Recirculate fuel oil service tank
  - Conduct auxiliary fuel oil transfer
- Oil lab infrequent evolutions (annually, elective)
  - Conduct lube oil BS&W
  - Conduct fuel oil BS&W
- Sounding and security routine evolutions (quarterly, core)
  - Don EEBD
  - Align/operate/secure eductor
- Sounding and security infrequent evolutions (annually, elective)
  - Verify/align fire pump
- Switchboard routine evolutions (quarterly, core)
  - Don EEBD
  - Shift control to switchboard
- Switchboard infrequent evolutions (annually, elective)
  - Start/parallel GTG/SSDG
  - Remove load/stop GTG/SSDG
  - Parallel bus to bus
- MLOC evolutions (quarterly, core)
  - Test EOT
  - Propeller pitch control test

- Verify/align bleed air system (including prairie and masker air)
- Inspect GTM module
- Verify/align GTM synthetic L/O
- Verify/align CRP/CPP system
- Inspect GTG module
- Verify/align LPAC
- Verify/align LPAD
- Verify/align MRG L/O system
- Engage/disengage turning gear
- Start turning gear forward/reverse direction
- Verify S/W cooling/service alignment
- Pressure/test L/O strainer
- Verify/align SWS pump
- Verify/align SWS system
- Verify/align F/O compensating system
- Verify/align F/O service system
- Start F/O pumps
- Start L/O pumps
- Start CRP/CPP pump
- Verify/align/test steering gear
- Verify/align AFFF system
- Shift to ship's power

Table A.2
DDG-51 Mission-Area Exercises

Mission Area/Exercise	Periodicity
Antimine Warfare	
AMW-1-SF Naval Surface Fire Support Rehearsal	[12, 18, 24]
AMW-2/3-SF Naval Surface Fire Support Qualification	[12, 18, 24]
Air Warfare	
AW-2-SF Link-11 Operations	[24, 0, 0]
AW-4-SF Anti-Air Target Designation and Acquisition (Non-Firing)	[24, 0, 0]

Table A.2—Continued

Mission Area/Exercise	Periodicity
AW-6-SF Air Target Detection, Track, Designation & Acquisition	[24, 0, 0]
AW-7-SF Tactical Anti-Air Warfare	[3, 6, 9]
AW-11A-SF Subsonic Anti-Ship Missile Defense Stream Raid	[24, 0, 0]
AW-12-SF Anti-Air Gunnery	[24, 0, 0]
AW-15-SF Info Procedures	[24, 0, 0]
AW-17-SF Link-11 Intrusion-Jamming	[24, 0, 0]
AW-20-SF CIWS Readiness Evaluation	[24, 0, 0]
AW-21-SF CIWS Firing	[24, 0, 0]
AW-24-SF Detect-to-Engage Sequence (Non-Firing)	[24, 0, 0]
AW-26-SF Link 4A Aircraft Intercept Control	[24, 0, 0]
AW-27-SF Super-Sonic ASMD (Simulation) Low Altitude	[24, 0, 0]
AAW-3-I Aircraft Intercept Control	[24, 0, 0]
AAW-4-I Lost-Plane Homing	[24, 0, 0]
AAW-5-I Anti-Air Target Designation/Acquisition in a Multi-Target Environment	[24, 0, 0]
AAW-7-I Electronic Counter–Counter Measures—Combat Air Patrol Coordination in Mechanical Jamming	[24, 0, 0]
AAW-8-I Tactical AAW Combat Air Patrol/Missile Coordination	[24, 0, 0]
AAW-9-I Tactical AAW Combat Air Patrol/Missile Coordination with Countermeasures	[24, 0, 0]
AAW-10-I Coordinated Combat Air Patrol/Missile Employment	[24, 0, 0]
AAW-11-I Coordinated Combat Air Patrol/Missile Employment in ECM Environment	[24, 0, 0]
AAW-13-I Combined In-Port Training Exercise	[24, 0, 0]
AAW-14-I Aircraft Control–Anti-Ship Missile Platform/ASM Intercept	[24, 0, 0]
Antisubmarine Warfare	
ASW-1-SF Surface Vessel Torpedo Tube Loading	[3, 6, 9]

Table A.2—Continued

Mission Area/Exercise	Periodicity
ASW-2-SF Sonar Casualty Drill	[3, 6, 9]
ASW-8-SF Active ASW Operations	[3, 6, 9]
ASW-11-SF Unidentified Contact Reporting	[3, 6, 9]
ASW-15-SF Submarine Familiarization	[12, 0, 0]
ASW-18-SF ASW Surface Vessel Torpedo Tube Attack Operations	[3, 6, 9]
ASW-19-SF ASW Rocket Thrown Torpedo Attack Operations	[24, 0, 0]
ASW-21-SF Passive ASW Operations	[3, 6, 9]
ASW-41-SF LAMPS Mk III Helo Control	[24, 0, 0]
ASW-46-SF ASW Mission Planning	[3, 6, 9]
ASW-48-SF Acoustic Data Collection Operations	[3, 6, 9]
ASW-50-SF ASW Attack Operations (Simulated)	[3, 6, 9]
ASW-51-SF ASW Torpedo Countermeasures Operation	[3, 6, 9]
ASW-54-SF Surface Ship Small-Object Avoidance	[24, 0, 0]
Command and Control Warfare	
C2W-2-SF Electronic Surveillance, Detection, and Analysis and Report	[3, 6, 9]
C2W-3-SF Extended Emission Control	[3, 6, 9]
C2W-4-SF Emission Control Set and Modification	[3, 6, 9]
C2W-5-SF Satellite Vulnerability	[3, 6, 9]
C2W-6-SF Watch Evaluation	[3, 6, 9]
C2W-7-SF Comprehensive Electronic Warfare Exercise Phase I	[12, 18, 24]
C2W-8-SF Comprehensive Electronic Warfare Exercise Phase II	[12, 18, 24]
C2W-9-SF Comprehensive Electronic Warfare Exercise Phase III	[12, 18, 24]
C2W-10-SF Coordinated Multi-Ship Electronic Warfare	[12, 18, 24]
C2W-11-SF Chaff Firing	[6, 12, 18]
C2W-12-SF LAMPS Mk III Underway Demonstration	[12, 18, 24]

Table A.2—Continued

Mission Area/Exercise	Periodicity
C2W-13-SF Missile/Threat Electronic Attack	[12, 18, 24]
C2W-14-SF EW Assessment	[12, 18, 24]
C2W-15-SF MK36 Decoy Load Exercise	[6, 12, 18]
C2W-16-SF Coordinated Chaff Firing	[12, 18, 24]
C2W-30-SF Detection, Classification, Tracking and Reporting	[3, 6, 9]
C2W-33-SF Tactical Air Targeting	[12, 18, 24]
C2W-37-SF Radio Direction Finding Exercise	[12, 18, 24]
C2W-38-SF Cryptologic Stimulator Exercise	[1, 2, 3]
Command, Control, and Communications	
CCC-1-SF SYSCON Fleet Broadcast	[3, 6, 9]
CCC-2-SF Communications Operational Planning	[6, 12, 18]
CCC-3-SF Helo Low-Visibility Control	[6, 12, 18]
CCC-4-SF SYSCON Ship Termination	[3, 6, 9]
CCC-5-SF SYSCON Secure Voice	[3, 6, 9]
CCC-6-SF Radiotelephone Drills	[3, 6, 9]
CCC-7-SF Tactical Maneuvers	[3, 6, 9]
CCC-8-SF Teletype Circuit Procedures	[3, 6, 9]
CCC-9-SF Flaghoist	[3, 6, 9]
CCC-10-SF Flashing Light	[3, 6, 9]
CCC-11-SF Semaphore	[3, 6, 9]
CCC-12-SF Imitative Deception	[6, 12, 18]
CCC-13-SF Emergency Action Procedures Emergency Destruction	[6, 12, 18]
CCC-15-SF Navy Tactical Display System Initiation and Operations	[3, 6, 9]
CCC-16-SF Aegis Doctrine Management	[6, 12, 18]
CCC-17-SF Link-11 Fast Frequency Changes	[3, 6, 9]

Table A.2—Continued

Mission Area/Exercise	Periodicity
CCC-19-SF Comprehensive Communications Assessment	[24, 0, 0]
CCC-20-SF SYSCON Special Intelligence Termination Teletype/Zulu Termination	[6, 12, 18]
CCC-21-SF SYSCON Operational Intelligence Broadcast/Special Intelligence Communications	[6, 12, 18]
CCC-22-SF SYSCON Special Reporting and Coordination Net (Romeo System)	[6, 12, 18]
CCC-23-SF Critic Handling Exercise	[3, 6, 9]
CCC-24-SF SYSCON Narrow Band/Wide Band Satcom	[3, 6, 9]
CCC-25-SF SYSCON Super High Frequency Satcom	[3, 6, 9]
CCC-26-SF SYSCON Extreme High Frequency Satcom	[3, 6, 9]
CCC-29-SF Officer in Tactical Command Information Exchange System / Tactical Data Information Exchange System System	[3, 6, 9]
CCC-30-SF Over-the-Air Transfer/Rekey	[3, 6, 9]
CCC-32-SF SYSCON Demand Assigned Multiple Access	[3, 6, 9]
CCC-33-SF SYSCON Havequick 11	[3, 6, 9]
CCC-34-SF SYSCON Single Audio System and Black Audio Switch	[3, 6, 9]
CCC-35-SF SYSCON Naval Modular Automated Communications System	[3, 6, 9]
CCC-36-SF Special Intelligence Automated Digital Network System Communications Operations	[3, 6, 9]
CCC-37-SF Automated Digital Network System Communications Operations	[3, 6, 9]
CCC-38-SF SYSCON International Maritime Satellite Communications	[3, 6, 9]
CCC-39-SF SYSCON 5 khz Satcom	[3, 6, 9]
CCC-40-SF SYSCON Information Systems	[3, 6, 9]
CCC-41-SF Information Assurance	[3, 6, 9]
CCC-42-SF Link-11 Operations	[3, 6, 9]

Table A.2—Continued

Mission Area/Exercise	Periodicity
CCC-43-SF Link-16 Operations	[3, 6, 9]
CCC-44-SF Multi-Link Operations	[6, 12, 18]
CCC-45-SF Satellite Link-11 Operations	[6, 12, 18]
CCC-46-SF Satellite Link-16 Operations	[6, 12, 18]
Fleet Support Operations–Medical	
FSO-M-1-SF Battle Dressing Station	[6, 12, 18]
FSO-M-2-SF Personnel Casualty Transport	[6, 12, 18]
FSO-M-3-SF Compound Fractures	[3, 6, 9]
FSO-M-4-SF Sucking Chest Wound	[3, 6, 9]
FSO-M-5-SF Abdominal Wound	[3, 6, 9]
FSO-M-6-SF Amputation	[3, 6, 9]
FSO-M-7-SF Facial Wound	[3, 6, 9]
FSO-M-8-SF Electric Shock	[3, 6, 9]
FSO-M-9-SF Mass Casualty	[6, 12, 18]
FSO-M-10-SF Smoke Inhalation	[3, 6, 9]
FSO-M-11-SF Burns	[3, 6, 9]
Intelligence	
INT-1-SF(BF) Aircrew Event Brief	[6, 12, 18]
INT-2-SF(BF) Aircrew Event Debrief	[6, 12, 18]
INT-2-SF(MS) Intel Collection and Reporting	[1, 2, 3]
INT-3-SF(BF) Intel Area Threat Brief	[1, 2, 3]
INT-6-SF(IS) Intel Information Retrieval	[1, 2, 3]
INT-6-SF(OP) Operational Intelligence Data Collation	[3, 6, 9]
INT-7-SF(IS) Operational Intelligence	[2, 4, 6]
INT-7-A(MS) Airborne Maritime Surveillance	[6, 12, 18]

Table A.2—Continued

Mission Area/Exercise	Periodicity
INT-7-SF(OP) Intel Support to Force Protection Planning	[1, 2, 3]
INT-8-SF(OP) Intel Support to Maritime Interdiction Operations	[2, 4, 6]
INT-10-A(MS) Airborne Maritime Photography and Rigging	[6, 12, 18]
Mobility–Damage Control	
MOB-D-2-SF Relief of Vital Stations	[3, 6, 12]
MOB-D-3-SF Manning Battle Stations	[1, 2, 3]
MOB-D-4-SF Emergency Interior Communications	[3, 6, 12]
MOB-D-5-SF Topside Damage	[3, 6, 12]
MOB-D-6-SF Righting Ship	[18, 0, 0]
MOB-D-7-SF Providing Casualty Power	[6, 12, 18]
MOB-D-8-SF Major Conflagration	[6, 9, 12]
MOB-D-9-SF Main Prop Space Fire (In Port)	[3, 6, 9]
MOB-D-10-SF Rescue/Assistance (In Port/Underway)	[6, 12, 18]
MOB-D-11-SF Setting Material Condition: Phase 1 Yoke, Phase 2 Zebra	[3, 6, 12]
MOB-D-12-SF Underwater Hull Damage Phases 1 and 2	[3, 6, 12]
MOB-D-13-SF Shoring	[3, 6, 9]
MOB-D-14-SF Fire Extinguishing Smoke Clearing	[1, 2, 3]
MOB-D-15-SF Chemical Attack	[6, 12, 18]
MOB-D-20-SF Isolate/Patch Damaged Pipe	[3, 6, 12]
MOB-D-21-SF Major Flood Main Propulsion Space	[3, 6, 12]
MOB-D-24-SF Darken Ship	[6, 12, 18]
MOB-D-26-SF Aircraft Fueling Station Fire	[3, 6, 12]
MOB-D-27-SF Helo Crash Firefighting	[1, 2, 3]
MOB-D-31-SF Toxic Gas	[3, 6, 9]

Table A.2—Continued

Mission Area/Exercise	Periodicity
Mobility-Navigation	
MOB-N-1-SF Navigation in an EW Environment	[6, 12, 18]
MOB-N-2-SF Open Ocean Navigation	[3, 6, 9]
MOB-N-3-SF Conning and Steering at Secondary Control Station	[6, 12, 18]
MOB-N-4-SF Harbor Piloting by Gyro (Day and Night)	[3, 6, 9]
MOB-N-5-SF Precision Anchorage (Day and Night)	[6, 12, 18]
MOB-N-6-SF Low Visibility Piloting	[3, 6, 9]
MOB-N-7-SF Piloting—Loss of Gyrocompass	[3, 6, 9]
MOB-N-9-SF Loss of Steering Control	[3, 6, 9]
Mine Warfare	
MIW-8.6-SF Transiting Mineable Waterways	[12, 18, 24]
MIW-8.7-SF Transit Swept Channel	[3, 6, 9]
Seamanship	
MOB-S-2-SF Heavy Weather	[12, 18, 24]
MOB-S-3-SF Precision Anchoring (Day)	[12, 18, 24]
MOB-S-3-SF Precision Anchoring (Night)	[12, 18, 24]
MOB-S-4-SF Moor to Buoy	[12, 18, 24]
MOB-S-5-SF Moor Alongside Pier or Ship at Anchor	[18, 12, 24]
MOB-S-6-SF Man Overboard—Day	[3, 6, 9]
MOB-S-6-SF Man Overboard–Night	[3, 6, 9]
MOB-S-7-SF Preparations to Abandon Ship	[12, 18, 24]
MOB-S-8-SF Vertical Replenishment	[6, 12, 18]
MOB-S-9-SF Underwater Transfer (Synthetic Highline)	[12, 18, 24]
MOB-S-10-SF Underwater Fuel (Day)	[6, 12, 18]
MOB-S-10-SF Underwater Fuel (Night)	[6, 12, 18]

Table A.2—Continued

Mission Area/Exercise	Periodicity
MOB-S-11-SF Emergency Breakaway (Day)	[6, 12, 18]
MOB-S-11-SF Emergency Breakaway (Night)	[6, 12, 18]
MOB-S-12-SF Tow and Be Towed	[12, 18, 24]
MOB-S-13-SF Helo Land/Launch	[3, 6, 9]
MOB-S-14-SF Search and Rescue Exercise	[12, 18, 24]
MOB-S-15-SF Helicopter In-Flight Refueling	[12, 18, 24]
MOB-S-16-SF Underway Provision, Rearm, Missile Transfer	[12, 18, 24]
MOB-S-16-SF Underway Provision, Rearm, Missile Transfer—Night	[12, 18, 24]
MOB-S-18-SF Get U/W with Duty Section	[12, 18, 24]
MOB-S-25-SF A/C On-Deck Refuel	[3, 6, 9]
MOB-S-34-SF Rescue Swimmer	[3, 6, 9]
Noncombat Operations	
NCO-1-SF Preps for Electronic Spaces	[3, 6, 9]
NCO-2-SF Assistance to Remote Spaces	[3, 6, 9]
NCO-3-SF Investigation and Reporting	[6, 12, 18]
NCO-4-SF Report of Electronic Casualties	[6, 12, 18]
NCO-5-SF Equipment Casualty Repair (Electronic Systems) During Loss of Lighting	[6, 12, 18]
NCO-6-SF Use of Installed Spare Fuses	[6, 12, 18]
NCO-8-SF Phone Casualty (Electronic System Spaces)	[6, 12, 18]
NCO-9-SF Secondary Electronic Casualty Control	[6, 12, 18]
NCO-10-SF Electronic Cooling/Chill Water Casualty	[6, 12, 18]
NCO-11-SF Class C Fire Electronic Spaces	[3, 6, 9]
NCO-12-SF Equip Casualty Repair	[3, 6, 9]
NCO-13-SF Use of ECC/CSOSS Manual	[3, 6, 9]
NCO-14-SF Drawing Emergency Elect Spares	[3, 6, 9]

Table A.2—Continued

Mission Area/Exercise	Periodicity
NCO-15-SF Alternative Power Source	[3, 6, 9]
NCO-16-SF ECC/Electronic Systems Spaces	[12, 18, 24]
NCO-19-SF Small Arms Qualifications	[6, 12, 18]
NCO-28-SF Rules of Engagement	[3, 6, 9]
NCO-29-SF Defense vs. Underwater Swimmers	[12, 18, 24]
NCO-30-SF Ship Penetration-Basic	[1, 2, 3]
NCO-32-SF Terrorist A/C Attack	[6, 12, 18]
NCO-33-SF Small Boat Attack	[6, 12, 18]
NCO-34-SF Bomb Threat	[6, 12, 18]
NCO-35-SF Hostage Situation	[6, 12, 18]
NCO-36-SF Floating Device	[12, 18, 24]
NCO-38-SF Visit, Board, Search, and Seizure	[6, 12, 18]
NCO-39-SF Force Protection (Pierside) Planning Exercise	[6, 12, 18]
NCO-40-SF Force Protection (Pierside) Plan Execution Exercise	[18, 24, 0]
NCO-41-SF Force Protection (Waterside) Planning Exercise	[6, 12, 18]
NCO-42-SF Force Protection (Waterside) Plan Execution Exercise	[18, 24, 0]
Strike Warfare	
STW-1-SF Mission Data Update	[3, 6, 9]
STW-21-A Simulated Tomahawk C/D Launch	[6, 12, 18]
Surface Land-Attack Missile Exercise (SLAMEX)	[3, 6, 9]
Surface Warfare	
SUW-1-SF Combined Air/Surface Tracking	[3, 6, 9]
SUW-2-SF Long Range Passive Tracking & Targeting	[3, 6, 9]
SUW-5-SF High-Speed Maneuvering Surface Threat	[12, 15, 18]
SUW-7-SF Alternate Local Control Long Range Fire, High-Speed Target	[12, 15, 18]

Table A.2—Continued

Mission Area/Exercise	Periodicity
SUW-9-SF Surface Tracking (NTDS) (Aegis)	[3, 6, 9]
SUW-10-SF Over-the-Horizon Targeting	[3, 6, 9]
SUW-12-SF Visual Identification Counter	[6, 12, 18]
SUW-13-SF Attack/Reattack Exercise for Surface-to-Surface Missile Ships	[6, 12, 18]
SUW-14-SF Surface Action Group LAMPS Tactics	[6, 12, 18]
SUW-17-SF High Speed Surf Engagement	[6, 12, 18]
SUW-18-SF Data Base Management	[6, 12, 18]
SUW-19-SF High Speed Quickfire Exercise	[6, 12, 18]
SUW-1-I Over the horizon Surveillance, Search & Detection	[6, 12, 18]
SUW-2-I Surface Action Group Tactics with Fixed-Wing Aircraft Support	[6, 12, 18]
SUW-3-I SUW Freeplay Exercise	[6, 12, 18]

APPENDIX B

Survey of Available Simulators

An important part of our research was to survey available simulators. We documented our survey and generated a database of maritime simulators and simulations for surface force training. We compiled simulator information from the following five main data sources:

- Department of the Navy, COMNAVSURFORINST 3502.1C, "Surface Force Training Manual," January 1, 2006
- Jane's Information Group, Jane's Simulation and Training Systems database, 2007
- A list of UK Royal Navy simulators provided by a contact in the Royal Navy
- Mentions of simulators in articles read or written by contacts, in interviews, or during host visits
- Vendor visits at the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) in December 2006 and follow-up correspondence or visits to company websites.

This last data source requires some explanation. During project team attendance at I/ITSEC, one team walked the entire length and width of the exhibitor floor and visited more than 350 vendor booths. He inspected each booth for evidence of vendor involvement in maritime domain simulation activities. Where he found such evidence, he took notes or collected material regarding these activities. When approached by a vendor while surveying a booth (a fairly frequent occurrence), he asked about that vendor's involvement in maritime simulation. A surprisingly large proportion of vendors indicated at

least some involvement in maritime simulation, even when such activities were not highlighted in their booth.

Our survey of available maritime simulation technologies is provided in Tables B.1 through B.4. This list is not exhaustive—we recognize that there are simulators available or in use by navies (perhaps even the U.S. Navy) that we failed to capture in our database. However, we are confident that our compilation of simulators captures the vast majority of simulators available for maritime training for the surface force and that it is broadly representative of simulator availability in this area. Note that simulators with U.S. Navy equivalency are presented Table C.1

The first columns of Tables B.1 through B.4 present just over 200 discrete simulators and are derived from our database of simulation technologies. Note that, when combined, the tables contain 197 discrete data rows, some of which present a suite of simulators (for example, the dozen or so commercial engine room simulators sold by Kongsberg) in a single row. Also note that the tables may contain a very small number of redundancies that result when a system is referred to by (or employed under) different names. Whenever possible, the project team has included the name of the simulator manufacturer.

In the final column of each table, the project team notes whether the simulator contributes training value to one or more of the following mission areas:

1. mobility-seamanship (MOB-S)
2. mobility-engineering (MOB-E)
3. command and control warfare (C2W)
4. mobility-navigation (MOB-N)
5. surface warfare (SUW)
6. air warfare (AW)
7. antisubmarine warfare (ASW)
8. command, control, and communications (CCC)
9. mine warfare (MIW) (includes electronic warfare [EW])
10. noncombat operations (NCO) (includes antiterrorism/force protection [AT/FP])
11. antimine warfare (AMW)

12. strike warfare (STW)
13. fleet support operations–medical (FSO-M)
14. intelligence (INT)
15. mobility–damage control (MOB-D).

Table B.1 presents only those surface force simulators that are U.S. Navy–equivalency certified. The equivalency certification means that an exercise conducted on the simulator counts toward readiness reporting. (Non-equivalency simulators can be used for practice, but do not count toward periodic exercise and drill-based training requirements.) A total of 17 simulators are certified for equivalency or partial equivalency.

Table B.1
Surface Training Simulators Certified for U.S. Navy Equivalency, by Mission Area

Abbreviation	Simulator	Manufacturer	Mission Area
TACDEW	Tactical Advanced Combat Direction and Electronic Warfare System		EW, C2W, AW, SUW, ASW
ITS/TCD	Integrated Training System/Trainer Control Device		ASW
COLT	Cryptologic Online Trainer		C2W
20E19	Naval Gunfire Support Training Device		SUW
CMTpc	Cruise Missile Trainer Portable Computer		STW
PROVT	Portable Radar Operator Video Trainer		AW, SUW
BFTT (portable)	Portable Battle Force Tactical Training System (formerly Carry-On Combat System Trainer)		AW, C2W, CCC, SUW, ASW
BFTT	Battle Force Tactical Training System		AW, C2W, CCC, STW, SUW, ASW

Table B.1—Continued

Abbreviation	Simulator	Manufacturer	Mission Area
ACTS	Aegis Combat Training System, Mk 29 and Mk 50		AW, CCC, SUW, ASW
VSS	Video Simulation System, SM-441		AW, SUW
SQQ-89 OBT	AN/SQQ-89 Onboard Training Device		SUW, ASW
T5/T6	Passive/Active Aegis AN/SQS-53A Sonar Simulator		SUW, ASW
BEWT	Battle Force Tactical Training System Electronic Warfare Trainer		EW, C2W
EWBOT	S10H7 Electronic Warfare Onboard Trainer		EW, C2W
SSQ-91	Combat System Training Simulator AN/SQQ-91 for LHD-Class Ships		AW, CCC
SSQ-94	Mine Countermeasures Simulator AN/SQQ-94 for MCM/MHC		MIW

Table B.2 presents simulators that are *not* U.S. Navy–equivalency certified. Our table includes both existing simulators and those whose delivery is pending. These simulators are scattered through the schoolhouses and other U.S. Navy organizations. As with other elements in the database, it is reasonably likely that we failed to include one or more simulators.

Table B.2
Surface Training Simulators Not Certified for U.S. Navy Equivalency, by Mission Area

Abbreviation	Simulator	Manufacturer	Mission Area
14A12	Surface ASW Trainer		ASW
NSST	Navigation, Seamanship, and Ship-Handling Training		MOB-N, MOB-S
	FATS Small Arms Trainer		AT/FP

Table B.2—Continued

Abbreviation	Simulator	Manufacturer	Mission Area
MMTT	Multi-Mission Tactical Trainer		AT/FP, AW, SUW
Device 11E15	Motor Alternating Current Two Speed & Controllers Trainer		AW, CCC
Device 11E18	Small Craft Electrical System Trainer		MOB-E
Device 19A8	Throttleman Watchstation Trainer		MOB-S
Device 19A10	Ship Service Electrical Switchboard Trainer		MOB-E
Device 19D1	DD963 Generator Ships Service Gas Turbine Control Panel		MOB-E
Device 19E3	ECSS Operator & Maintenance Trainer		MOB-E
Device 19E49	Electrical Circuitry Display Trainer		MOB-E
Device 19G2	Gl-47 Simulator/Stimulator		MOB-E
Device 19G4	Gas Turbine Propulsion Plant Trainer		MOB-E
Device 19H3	ARS-50 Propulsion Engineer System Operator/Maintenance Trainer		MOB-E
Device 19H4 or 5	LSD-41 Class Mach Plant Control System Operator/Maintenance Trainer		MOB-E
Device 20H4	Dockside Underway Replenishment Simulator Trainer		MOB-S
Device 20H5/A	DD-983 Engineering Control/ Surveillance System Operator Trainer and DD-963 ECSS Operations Trainer		MOB-E
Device 20H6 /A	FFG-7 Propulsion Eng Control Systems Operator Trainer		MOB-E
Device 20H6B	FFG-7 Propulsion Engineering Control Station Operations Trainer in Van		MOB-E

Table B.2—Continued

Abbreviation	Simulator	Manufacturer	Mission Area
Device 20H7A	FFG-7 Propulsion Engineering Control System Maintenance Trainer		MOB-E
	Battle Stations 21		MOB-S, MOB-D
COVE	Conning Officer Virtual Environment		MOB-N, MOB-S, AT/FP
Full Mission Bridge/ TaCOVE Ship Handling Simulation	Full Mission Bridge/Tactical Conning Officer Virtual Environment Ship Handling Simulation	Marine Safety International	MOB-N, MOB-S, AT/FP
LCS Bridge Simulator	Littoral Combat Ship Bridge Simulator		MOB-N, MOB-S, MOB-E
	ARVCOP Ship-Handling System	Technology Systems, Inc.	MOB-N, MOB-S
FMSS	Full Mission Ship-Handling Simulator	Ship Analytics	MOB-N, MOB-S
PCBECCEs	PC-Based Training For Basic Engineering Casualty Control Exercises	Delex Systems, Inc.	MOB-E
DDG-51 TAO GRTS	Prototype Use of Generic Reconfigurable Training System for DDG-51 TAO Training		AW, CCC
Device 2H111	Landing Signal Officer Trainer		AW, CCC
Program	Human Patient Simulation Program		FSO-M
	SPAWAR Naval Simulation System		C2W
TSTS	Total Ship Training System		MOB-N, MOB-D, MOB-E
Kill Chain	Kill-Chain Application	Mantech	ASW
DCS	Damage-Control System	CAE	MOB-D

Table B.2—Continued

Abbreviation	Simulator	Manufacturer	Mission Area
TASWIT	Tactical Advanced Simulated Warfare Integrated Trainer Naval Warfare Trainer	Sonalysts/ Northrop Grumman	AW, C2W, CCC, SUW, ASW
RSC ITA	Radar System Controller Intelligent Training Aid		AW, SUW
NAVTAG	Naval Tactical Game	NG-IT	AW, C2W, CCC, SUW, ASW
OTD	Countermeasures Operator Training Device	NG-IT	EW
SSTS	AN/SLQ-32 (V) Software Support and Training System	NG-IT	EW
OBT	Navy Onboard Trainer Suite–SQQ-89	AAI	ASW
MAST	Mission Avionics System Trainer Naval SIGINT Trainer	CACI	C2W
OBT	Sonar Onboard Trainer	Lockheed Martin	ASW
DRS AN/SQQ-T1 or T1A	Sonar Training Sets		ASW
HET	Harpoon Embedded Trainer	Delex Systems, Inc.	SUW
ETD	Harpoon External Training Device	Delex Systems, Inc.	SUW
HITTS	Harpoon Interactive Tactical Training System	Delex Systems, Inc.	SUW
Mk 30 and Mk 39	Launchable ASW Sonar Stimulators		ASW

Table B.3 presents simulators used by other navies worldwide, including the UK Royal Navy.

Table B.3
Surface Training Simulators Used by Other Navies

Abbreviation	Simulator	Manufacturer	Mission Area
FATS-MITS	FATS Motion Integrated Training System (for Ship Weapons)		SUW
	Sonar and Mine-Hunting Simulation	RDE	MIW
	ASW Simulation	RDE	ASW
	CIC Trainer	RDE	AW, C2W, CCC, SUW, ASW
MCOT	Minehunter Command and Operator Trainer	RDE	MIW
	Ship Weapon Firing Procedure Trainer	RDE	SUW
IVR or IVR HD-180	Immersive Small Arms Trainer or Immersive Small-Arms Trainer HD-180	VirTra Systems	AT/FP
	CIC Trainer	RDR, Inc.	AW, C2W, CCC, SUW, ASW
	Naval Tactical Trainer	BVR Systems	AW, C2W, CCC, SUW, ASW
FISTSTM	Fleet Instrumented Sea Training System		AW
Proteus ASTT	Proteus Action Speed Tactical Trainer	Kongsberg (KDA)	AW, C2W, CCC, SUW, ASW
Proteus ASW	Proteus ASW Trainer	Kongsberg	ASW
	Polaris Bridge Simulator	Kongsberg	MOB-N, MOB-S
	Ship Air Defence Dome Trainer	Kongsberg	AW
	Helmsman Training Simulator	H Scientific	MOB-N, MOB-S
	Radio Communications Trainer	H Scientific	CCC

Table B.3—Continued

Abbreviation	Simulator	Manufacturer	Mission Area
	Full-Bridge Simulator	H Scientific	MOB-N, MOB-S
NMWS	Naval Mine Warfare Simulator		MIW
	Gunnery Simulator (Virtual 20/30-mm Weapon)	Virtalis	SUW
ORTT	Operations Room Team Trainer		AW, C2W, CCC, SUW, ASW
AAW	Naval Anti-Air Warfare Simulator		AW, C2W, CCC
GSS	PC-Based Generic Sonar Simulator	DSIT	ASW
Fleetman	Fleetman Naval Training System	DT Media	AT/FP, AW, CCC, MOB-N, MOB-S, SUW
NEWS	Naval EW Simulator		EW
CIC	Naval CIC Simulator	L-3 MPRI Ship Analytics	AW, C2W, CCC, SUW, ASW
ASTT	Action Speed Tactical Trainer	L-3 MPRI Ship Analytics	AW, C2W, CCC, SUW, ASW
	Bridge and Ship Handling Simulation	Transas Marine	MOB-N, MOB-S
	Mermaid 2100 Ship Manoeuvring Simulator Systems	Maritime Research Institute Netherlands	MOB-N, MOB-S
	Mermaid 2100 Full Mission Bridge Simulator	Maritime Research Institute Netherlands	MOB-N, MOB-S
	Desktop Ship Manoeuvre Simulator Systems	Maritime Research Institute Netherlands	MOB-N, MOB-S

Table B.3—Continued

Abbreviation	Simulator	Manufacturer	Mission Area
	Mermaid Ship Engine Room Simulator	Maritime Research Institute Netherlands	MOB-E
	Damage Repair Instruction Unit	VT Group	MOB-D
	Insyte NBC Defence Training System	BAE	MOB-N, MOB-S
PTU	Insyte Ship Nuclear, Biological, Chemical Protection Training Unit	BAE	AT/FP, MOB-D
MCMV	Mine Countermeasures Vessel Trainers	BAE	MIW
HCT	Helicopter Control Trainer	BAE	AW, CCC
CTT	Insyte operations room simulators and Command Team Trainers		AW, C2W, CCC, SUW, ASW
UNEWT	Insyte Universal Electronic Warfare Trainer		EW
	Insyte Onboard Radar Trainer		SUW
SIRAS	Insyte Surveillance and Identification Friend or Foe Radar Simulator		AW, SUW
NARSIM	Insyte Navigation Simulator	BAE	MOB-N, MOB-S
	Naval Weapon Simulators	BAE	AW, STW, SUW
GMOTS	Gun Maintenance and Operational Training System	BAE	SUW
LMOTS	Launcher Maintenance and Operational Training System	BAE	STW
FFTU	Fire Fighting Training Unit	Flagship UK F	MOB-D
	Ship Control Room Trainers	Pennant Training Systems Limited	MOB-E

Table B.3—Continued

Abbreviation	Simulator	Manufacturer	Mission Area
MAST	Marine Systems Trainer	eNGINU!TY	MOB-E
FEMS	Fleet Exercise Minelaying System	MSI-Defence	MIW
NCOT/ eTRAINER	Naval Combat Operator Trainer (eTRAINER) System	MacDonald Dettwiler	AW, C2W, CCC, SUW, ASW
AIEWS	Advanced Integrated Electronic Warfare System	Digital System	EW
CEC	Co-operative Engagement Capability	Digital System	STW, AW, SUW
VCS SIM	Virtual Combat System Simulator	NG-IT	AW, C2W, CCC, SUW, ASW
TRAD EG	Training/Readiness Assessment Device Radar Environment Generator	NG-IT	EW
IEWRS	Integrated Electronic Warfare Reprogramming System	NG-IT	EW
RVG	Ship Radar Video Generator Simulation System	NG-IT	AW, SUW
NTCT	Naval Tactical and Command Trainer	Elbit	AW, C2W, CCC, SUW, ASW
	Naval Electronic Warfare Trainer	Elbit	EW
NTT	Naval Tactical Training System	BVR	AW, C2W, CCC, SUW, ASW
CIC	Desitac Naval Tactical Trainer—CIC Simulation		AW, C2W, CCC, SUW, ASW
DCN MILDAV	Ship Visual Air Defence Simulator		AW
ENT	Embedded Naval Trainer—CIC Trainer	ISI Hellas	AW, C2W, CCC, SUW, ASW

Table B.3—Continued

Abbreviation	Simulator	Manufacturer	Mission Area
MERTS	Mobile Electronic Warfare and Radar Test System		EW
HI-TASS	High-Fidelity Towed Array Sonar Simulator	General Dynamics Canada	ASW
	Insyte Onboard Sonar Trainer	BAE	ASW
GASS	Generic Acoustic Stimulation System	Lockheed Martin	ASW
	Sonar Trainers	Kongsberg (KDA)	ASW
	Sonar Simulators	RDE	ASW
CMS	Canadian Towed Array Sonar System Mission Simulation	Array Systems Computing, Inc.	ASW
CGRT	V-Series Close Range Gunnery Trainer	LM UK	SUW
OBVACT	Onboard Visual Aimer Continuation Trainer	LM UK	SUW
	Ship's Weapon Simulators	AAI	SUW
Soundtrak	Soundtrak ASW Target Simulator	Thorn EMI Electronics, Ltd.	ASW
CONSORT	Royal Navy Bridge Trainer	CONSORT	MOB-N
ASUAT 11	Anti-Submarine Universal Attack Trainer		ASW
NEREUS	Acoustic Frequency Analysis Classification Trainer	NEREUS	ASW
	Command Team Trainer	Cook	AW, C2W, CCC, SUW, ASW
ASTT	Tactical Trainer		AW, C2W, CCC, SUW, ASW

Table B.3—Continued

Abbreviation	Simulator	Manufacturer	Mission Area
CSST	Communications Systems Simulations Trainer		CCC
	Phalanx Cubic Trainer (Close-In Weapons Support)		AW
SRMH MCR	Single Role Mine Hunter Machinery Control Room Simulator		MIW
	HUNT-Class MCM Vessels Engineering Trainer		MOB-E
	SEA DART Guided Weapons System 30 Skill Trainer	Cook	AW, SUW
	GSA1 SKILL TRAINER		SUW
PADT	Point Air Defence Trainer		AW
	GSA8 Skill Trainer		SUW
	T45 Navigation Trainer		MOB-N
	T45 Fully Integrated Communications System Trainer		CCC

Table B.4 lists commercially available simulators. These simulators are used either for nonmilitary-specific maritime training or were designed for military use but do not seem to have been adopted by a specific navy.

Table B.4
Other Commercially Available Surface Training Simulators

Abbreviation	Simulator	Manufacturer	Mission Area
MMTT	Multi-Mission Team Trainer		ASW, AW, SUW
DCTMS	Damage Control Training and Management System		MOB-D
ANS5000	ANS5000	RDE	MOB-N, MOB-S

Table B.4—Continued

Abbreviation	Simulator	Manufacturer	Mission Area
	Ship Engine Simulation	RDE	MOB-E
RASI	Radar and Navigational Aid Simulator	RDE	MOB-N
	Ship's Plant Simulator	Kongsberg	MOB-E
Engine Room Simulators	More than a dozen different engine room simulators, including diesel, combined, high speed, steam turbine, and gas turbine	Kongsberg	MOB-E x12
GMDSS	Global Maritime Distress & Safety System	Kongsberg	CCC
	Ship Handling and Piloting Simulator	MPRI	MOB-N, MOB-S
	Radar/Navigation Simulator	MPRI	MOB-N, MOB-S
	Engine and Machinery Team Simulation	MPRI	MOB-E
Tugsim	The Mistral 1000 (Tugsim) System	Kimberley TAFE	MOB-N
	Maritime Simulator	Sydac	MOB-N, MOB-S
SMART	Simulation for Maritime Assessment, Research and Training (Maritime Professional Training)		MOB-N, MOB-S
GMDSS	Global Maritime Distress & Safety System	TEEX	CCC
ERS	Ship engine room simulators	Transas Marine Limited	MOB-E
Advanced Marine–VS	Virtual Ship® (VS) series of ship handling simulators	CSC Advanced Marine	MOB-N, MOB-S
MISTRAL 4000	Full mission ship-handling simulator	Sindel (Italy)	MOB-N, MOB-S
MANSIM HSC	Ship-handling simulators for conventional, high-speed, and very-fast ships	Sindel	MOB-N, MOB-S

Table B.4—Continued

Abbreviation	Simulator	Manufacturer	Mission Area
	NavControl Ship's Bridge Simulator	Direction des Constructions Navales	MOB-N, MOB-S
	A variety of simulators for power, machinery, and engineering control	Direction des Constructions Navales	MOB-E
	Insyte reconfigurable ship's bridge simulators	BAE Systems	MOB-E, MOB-N
Ship Analytics	Diesel Engine Training Simulator—Ship Diesel Engine and Power-Generation Simulators	Haven	MOB-E
MPRI	Large Simulator System—Ship Diesel Engine Simulator	Haven	MOB-E
	Machinery simulators	MODEQ	MOB-E
	Ship machinery and systems trainers	CAE	MOB-E
	SonarPC Sonar Training System	AudioSoft	ASW

Analysis of Simulator Survey

We found that although equivalencies for U.S. Navy surface combatant training exist only for warfare areas, simulators are available for other mission areas. Simulators are playing an increasing role in training at the Surface Warfare Officer School (SWOS). SWOS has a number of simulators, including a full mission bridge, a conning officer virtual environment, a multi-mission team trainer, and engineering simulators.[1] The Navy owns and is acquiring a wide range of simulation tools spread across schoolhouses and other functional areas.

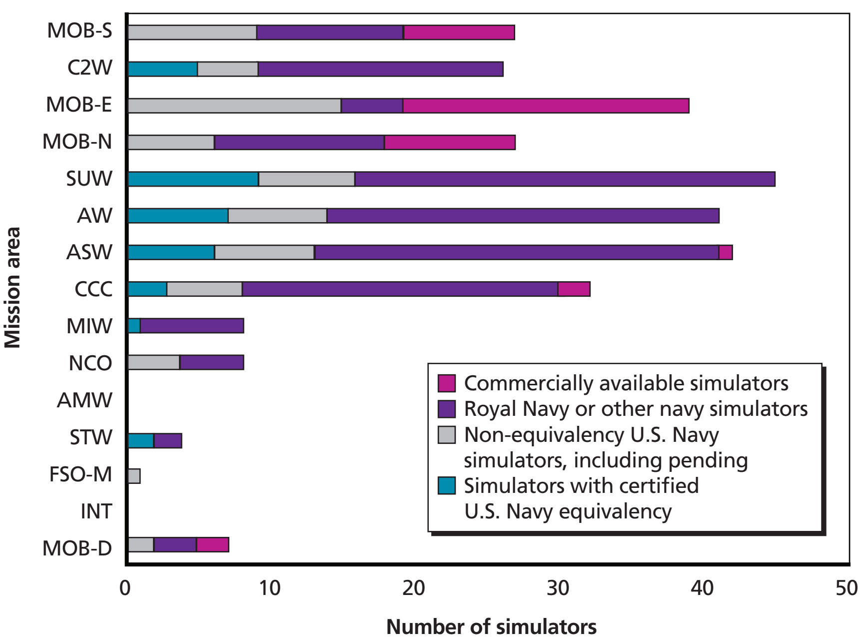
Simulators play a prominent role in training commercial maritime industry and other navies. Licensing authorities allow some remission

[1] See Edward Lundquist, N86 Public Affairs, "Simulators Offer Challenges to Improve Real Skills," *Surface Warfare*, Vol. 32, No. 2, Spring 2007.

of sea time through completion of simulator based training. In addition, some simulation is required prior to licensing, e.g., Automated Radar Piloting (ARPA).

There are a number of simulators in the Navy's inventories whose use does not result in training credit. For example, there are a number of ship-handling simulators at FCAs that are used to train junior officers in junior officer ship-handling training, but no credit is granted for their use; these simulators are included in the seamanship (MOB-S) category of simulators. Our survey also includes a review of which simulators are used by the U.K. Royal Navy and other navies. *Jane's Fighting Ships* has an extensive database that lists simulators and their use by the Royal Navy and all other navies worldwide. Figure B.1, derived from the data in Tables B.1 through B.4, shows the number

Figure B.1
Number of Simulators—U.S. Navy Equivalency and Non-Equivalency, UK Royal Navy and Other Navies, and the Commercial Sector



RAND *MG765-B.1*

of U.S. Navy simulators that do and do not provide equivalencies, the number used by other navies, and the number used by commercial industry. It is interesting to note that there are a great number of simulators for the tactical warfare mission areas, seamanship, navigation, and engineering.

At the IITSEC conference, the U.S. Navy displayed an interesting training-related capability: a full-size mockup of a ship in its basic training facility in Chicago. The mockup, named the USS *Trayer*, is a 210-foot replica of a guided missile destroyer. Under simulated conditions, recruits aboard the ship perform casualty control exercises that are in many ways more realistic than exercises found on actual ships in the fleet. Examples of the more than 15 types of scenarios that can be presented to recruits are line-handling, lookout, fires, and flooding. Controllable elements include flame and water effects, audio, strobe and lighting effects, and hot objects. The team that designed the USS TRAYER had to balance the need to create scenarios that posed physical challenges and emanated a sense of danger while maintaining acceptable safety levels for untested recruits.[2]

The commercial sector also uses simulators extensively. As Figure B.1 shows, a great number of simulators exist in the engineering, navigation, seamanship, and some damage-control areas. In the commercial sector, using simulators can lead to credit toward certification and validation.

Applied Research Internationals Full Mission Engine Room Simulator (FMERS) is a high-fidelity simulator for training marine engineers at watch keeping at the operational and management levels. The simulator consists of an engine room, a main engine control room, main switch board, simulated machinery space (including a mimic pipeline panel), and local operating stations.[3] FMERS can be used

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[2] Additional details about the USS *Trayer* facility can be found at Naval Service Training Command, "Battle Stations 21," undated.

[3] FMERS simulates the MAN B&W 6S60MC 6-cylinder, 2-stroke, reversible, slow-speed marine diesel main engine of firing order 1, 5, 3, 4, 2, 6. This engine is directly coupled to a fixed-pitch propeller and all the auxiliary systems that accompany such an installation in the main engine room of a tanker. See Applied Research International, "Engine and Propulsion–Full Mission Engine Room Simulator," undated.

to demonstrate 15 Standards of Training and Certification of Watch Standing competency requirements; nine of these competency requirements can be demonstrated on the Engine Room Part Task Trainer. Our survey also revealed that other companies, including Kongsberg and TRANSAS, manufacture engineering simulators.

The Total Ship Training System (TSTS)

We spoke with Naval Sea Systems Command authorities responsible for retrofitting DDG-51–class ships with engineering and other embedded trainers under a program called TSTS. The TSTS goal is to embed a total training simulation system into DDG-51–class ships. This is being accomplished by an extensive installation program that occurs during a ship's extended refit period. The system's embedded training system includes navigation, seamanship, and engineering trainers that are linked together in a single training system.

The greatest benefit we see from the TSTS system is that it provides an "embedded" engineering training capability that allows a crew's engineering teams to conduct EEC exercises on their own consoles. The TSTS allows the consoles to be put into a training mode. A major drawback is that TSTS installations are only being funded in small increments: Only two or three DDG-51–class ships are funded to receive the upgrade each year.

Simulators at Surface Warfare Officer School Command

The Navy's SWOS command provides a continuum of professional education and training in support of the Navy's surface community requirements and prepares officers to serve at sea. SWOS provides training for junior officers who have just began their service, midgrade officers who serve as department heads, and prospective executive and commanding officers in preparation for their afloat tours.

Simulators are playing an increasing role in the training conducted at SWOS. SWOS is continually striving to improve the way

warfighters are trained and has applied state-of-the-art technology to classrooms and trainers.

SWOS uses the following simulators, among others:

- *An extensive engineering simulator*. SWOS uses both a desktop trainer (that replicates the actions of engineering consoles found on DDG-51–class ships) and a full mockup of ship consoles. The consoles react to the actions of the operator exactly as the actual shipboard consoles do. Prospective engineering officers and engineering department heads practice engineering evolutions and casualty control exercises on this equipment.
- *A full mission bridge (FMB).* This simulator provides a three-dimensional, 360-degree field of view. The FMB is a virtual reality and projection technology for ship-handling training and is used to train sailors in procedures used in an antiterrorism/force protection scenarios and surface warfare tactics employment.
- *A Conning Officer Virtual Environment (COVE).* This helmet-mounted virtual reality simulator provides intensive ship-handling scenarios for conning officers. It is used to practice ship-handling events, such as entering and leaving port, underway replenishment, mooring and pier ship handling, and division tactics. The COVE can simulate the ship-handling characteristics of multiple ship types, different ports, and different weather conditions.
- *A multimission team trainer (MMTT)*. This multithreat, multiwarfare trainer was adopted from commercial off-the-shelf technology. Although the MMTT is not representative of any specific platform, it does provide training in watch team management, threat prioritization, and tactics employment.

SWOS is also responsible for developing and implementing training of the littoral combat ship (LCS) officers of the deck (OODs), readiness control officers (RCOs), and tactical action officers (TAOs). SWOS has an extensive LCS simulation suite. The LCS is totally new type of hull and it represents a new operational philosophy for U.S. Navy conning officers and bridge operations. The foundation of the curricula for this training is rooted in the U.S. Navy's train-to-qualify

concept, which establishes the objective to equip the prospective LCS OODs, RCOs, and TAOs with the mariner, engineering, and tactical skill sets required to proficiently and safely operate the ship immediately upon reporting aboard.

Unlike standalone trainers, the OOD and RCO components of the Full Mission Bridge (FMB) Trainer must be interoperable to accomplish realistic training up to and including the performance level of the qualification standards. The LCS FMB is approximately an 80-percent replication of the bridge of the LCS, including the placement of controls and seating positions. The LCS RCO instruction provides the knowledge and proficiency skills required to control the LCS propulsion, steering, and other auxiliary equipment during a wide range of expected operations.

Summary

The SURFTRAMAN only grants training equivalencies for warfare mission area exercises conducted on actual ship equipment. However, our survey indicates that many simulators are available (and in use by civilian industry and other navies) to conduct other mission-area exercises. Simulators play a prominent role in training the commercial maritime industry and other navies. Commercial licensing authorities allow some remission of sea time through completion of the simulator-based training.

We discovered that the U.S. Navy's wide range of simulation tools is spread across the schoolhouse and other functional areas. We also found that there are gaps in simulation capability. For instance, little simulation capability exists for cryptology, intelligence, and VBSS exercises. In other cases (such as ASW), the simulator's level of fidelity is inadequate. It is clear that some training events need to be and are best done at sea.

Simulators are being sought to provide a training capability and their use is increasing. The commercial maritime industry is using simulation to a greater degree, and we observed that the commercial simulation manufacturing industry is both responsive to and capable of requests for new technology—if you ask, they will build it.

APPENDIX C

Surface Propulsion Training Devices

This appendix lists surface propulsion training devices, the company that manufactured or upgraded them (if known), and their locations.

Table C.1
Surface Propulsion Training Devices

Device	Manufacturer	Location
11E15—Motor A/C Two Speed & Controllers Trainer	Fidelity (performed upgrade)	Ser 1–14—SSC, Great Lakes Ser 15—FTC, San Diego
11E18—Small Craft Electrical System Trainer	Ben Lorenz	Ser 1–6—SSC Ser 15–18, 20—SSC Great Lakes
19A8—Throttleman Watchstation Trainer	RDR (performed upgrade)	Ser 1–4—SSC, Great Lakes
19A10—Ship Service Electrical Switchboard Trainer	Simtronics	Ser 1—SWOS, Newport Ser 2–3—SSC, Great Lakes
19D1—DD963 Generator Ships Service Gas Turbine Control Panel	Ridgeway	Ser 1—SSC, Great Lakes
19E3—ECSS Operator & Maintenance Trainer	Singer/Litton GCSD	Ser 1—SSC, Great Lakes
19E49—Electrical Circuitry Display Trainer	ANTECH	Ser 1—FTC, San Diego Ser 2—FTC, Norfolk
19G2—GL-47 Simulator/Stimulator	Litton GCSD	Ser 1—SSC, Great Lakes
19G4—Gas Turbine Propulsion Plant Trainer	Newport News Shipbuilding/ DynCorp	Ser 1—SWOS, Newport

Table C.1—Continued

Device	Manufacturer	Location
19H3—ARS-50 Propulsion Engineer System Operator/ Maintenance Trainer	ELDEC	Ser 1—SSC, Great Lakes
19H4—LSD-41 Class Machinery Plant Control System Operator/ Maintenance Trainer	Lockheed/Tano	Ser 1—SSC, Great Lakes
19H5—LSD-41–Class Machinery Plant Control System Operator Trainer	Integrated Technologies	Ser 1—SWOS, Newport
20H4—Dockside Underway Replenishment Simulator Trainer		Ser 1—ATG, Mayport
20H5—DD-963 Engineering Control/Surveillance System Operator Trainer	Singer	Ser 1–2—SSC, Great Lakes (Ser 1 crated) Ser 3—Deleted from inventory Ser 4—SWOS, Newport
20H5—DD-963 ECSS Ops Trainer	Dynalantic	Ser 5—SWOS, Newport
20H5A—DD-963 ECSS Operations Trainer in Van	Dynalantic	Ser I—ATG PAC, San Diego
20H6—FFG-7 Propulsion Engineering Control System Operator Trainer	GE Daytona (performed upgrade)	Ser 1—SSC, Great Lakes
20H6A—FFG-7 Propulsion Engineering Control System Operator Trainer	Singer (performed upgrade)	Ser 1—SWOS, Newport
20H6A—FFG-7 Propulsion Engineering Control System Operator Trainer	Dynalantic (performed upgrade)	Ser 3—SWOS, Newport
20H6B—FFG-7 PECS Operations Trainer in Van	Dynalantic (performed upgrade)	Ser 1—ATG PAC, San Diego
20H7A—FFG-7 Propulsion Engineering Control System Operator Trainer	Singer (performed upgrade)	Ser 1—SSC, Great Lakes

Bibliography

Applied Research International, "Engine and Propulsion–Full Mission Engine Room Simulator," undated. As of June 25, 2008: http://www.ariworld.com/simulation/engine_propulsion_full_mission_1.asp

Clark, Summer, "Modernizing the DDG Fleet—A Total Ship Systems Approach," Wavelengths Online, May 17, 2005.

Department of the Navy, OPNAVINST 9200.3, Op-04P, "Engineering Operational Sequencing System (EOSS)," September 21, 1976.

Department of the Navy, CINCPACFLTINST 9261.1, "Ship's Fuel Maintenance System," December 13, 1993.

Department of the Navy, COMTHIRDFLTINST 9261.1, "PC EMPSKED Employment Terms / Fuel Factors," September 28, 1998.

Department of the Navy, OPNAV Notice 1500.57A, N869, "Surface Warfare Training Strategy," August 3, 1999.

Department of the Navy, COMNAVSURFORINST 3540.2, "Surface Force Engineering Readiness Process," March 8, 2002.

Department of the Navy, COMNAVSURFORINST 3540.3, "Engineering Department Organization and Regulations Manual (EDORM)," August 11, 2003.

Department of the Navy, COMCARSTRKGRUONEINST 3500.2G, N31, "Carrier Strike Group Composite Training Unit Exercise (COMPTUEX)," October 1, 2004.

Department of the Navy, OPNAVINST 3500.34F, "Personnel Qualification Standards (PQS) Program," June 13, 2005a.

Department of the Navy, OPNAVINST 3500.38B/MCO 3500.26/USCG COMDTINST M3500.1B, "Universal Naval Task List (UNTL)," Version 3.0, November 1, 2005b.

Department of the Navy, CFFCINST 3500.2, N70, "Fleet Synthetic Training (FST)," November 7, 2005c.

Department of the Navy, COMTHIRDFLT OPORD 201, "Appendix 3 to Annex T to COMTHIRDFLT OPORD 201 (U), Maritime Strike Group (CSG/ESG) Fleet Readiness Training Plan (FRTP) Sustainment Phase Training Events (U)," November 17, 2005d.

Department of the Navy, COMNAVSURFORINST 3502.1C, "Surface Force Training Manual," January 1, 2006a.

Department of the Navy, COMNAVSURFOR Message 101516Z, "Maintaining Warfare Certifications," May 2006b.

Department of the Navy, Commander, Second Fleet, "Annex U to COMSECONDFLT OPORD 2000-06 (U)," August 1, 2006c.

Department of the Navy, OPNAV Notice 3000.15, N09, "Fleet Response Plan (FRP)," August 31, 2006d.

Department of the Navy, COMSECONDFLT 07-001F, "FY07 Fuel Management Guidance 07-001F," November 2006e.

Department of the Navy, *Initial Capabilities Document for the Total Ship Training Capability (TSTC)*, unclassified draft, December 10, 2006f.

Department of the Navy, COMNAVSURFORINST 3502.1D, "Surface Force Training Manual," January 1, 2007a.

Department of the Navy, OPNAVINST 3500.38B/MCO 3500.26/USCG COMDTINST M3500.1B, "Navy Tactical Task List (NTTL)," January 30, 2007b.

Etnyre, VADM T. T., Commander, Naval Surface Forces, "Message from Commander, Naval Surface Forces," *Surface Warfare Magazine*, Vol. 32, No. 2, Spring 2007.

Jane's Information Group, Jane's Simulation and Training Systems database, 2007. As of June 1, 2007:
http://jsts.janes.com/public/jsts/index.shtml

Lundquist, Edward, N86 Public Affairs, "Simulators Offer Challenges to Improve Real Skills," *Surface Warfare*, Vol. 32, No. 2, Spring 2007.

National Research Council, Simulated Voyages: Using Simulation Technology to Train and License Mariners, Washington, D.C.: National Academy Press, 1996.

Naval Center for Cost Analysis, "Naval Visibility and Management of Operating and Support Costs (VAMOSC) 5.0: Detailed Ships—User Manual," February 28, 2006.

Naval Service Training Command, "Battle Stations 21," undated. As of July 11, 2008:
http://www1.netc.navy.mil/nstc/battle_stations_21_New.htm

Office of the Under Secretary of Defense (Acquisition and Technology), *Modeling and Simulation (M&S) Master Plan*, Washington, D.C., October 1995.

Osborne, John, "Prospective OODs for New LCS Train to Qualify," Navy Newsstand, Story No. NNS061114-12, November 14, 2006.

Paul, Christopher, Harry J. Thie, Elaine Reardon, Deanna Weber Prine, and Laurence Smallman, *Implementing and Evaluating an Innovative Approach to Simulation Training Acquisitions*, Santa Monica, Calif.: RAND Corporation, MG-442-OSD, 2006. As of June 19, 2008:
http://www.rand.org/pubs/monographs/MG442/

Salas, Eduardo, and Janis A. Cannon Bowers, "The Science of Training: A Decade of Progress," *Annual Review of Psychology*, Vol. 52, 2001, pp. 471–499.

Schank, John F., Harry J. Thie, Clifford M. Graf II, Joseph Beel, and Jerry M. Sollinger, *Finding the Right Balance: Simulator and Live Training for Navy Units*, Santa Monica, Calif.: RAND Corporation, MR-1441-NAVY, 2002. As of June 19, 2008:
http://www.rand.org/pubs/monograph_reports/MR1441/

Yardley, Roland J., Harry J. Thie, John F. Schank, Jolene Galegher, and Jessie Riposo, *Use of Simulation for Training in the U.S. Navy Surface Force*, Santa Monica, Calif.: RAND Corporation, MR-1770-NAVY, 2003. As of June 19, 2008:
http://www.rand.org/pubs/monograph_reports/MR1770/